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abstract

In an era where environmental consciousness is on the rise, Kao Chemicals is making substantial strides towards sustainability through the transformation of its product ranges. Among many different chemistries, Kao produces polyoxyethylene glycerine esters under the trade name of LEVENOL - products that perfectly fit with current market trends.
This article delves into the innovative journey of Kao's adaptation of the ethoxylated glycerine esters range towards its low carbon footprint versions, exploring its implications, applications, and the broader impact on sustainable practices.

Introduction

Pioneering Sustainability in Home Care Amidst Shifting Consumer Expectations

Nowadays there is a growing eco-consciousness in society. Consumers are particularly concerned about the health and environmental impact of the products they use. On the other hand, the European Green Deal has established a challenging roadmap plan for a sustainable Europe. So, the consumer industry must move towards a cleaner and sustainable economy, conditioning formulation design and therefore the selection of ingredients [1-2].

As we navigate the evolving landscape of the Home Care sector, consumer expectations are undergoing a profound transformation, fuelled by a heightened awareness of environmental concerns. In this changing environment, where sustainability is crucial, ingredient providers should emerge as trailblazers, aligning their product ranges with the shifting sands of consumer demands.

In the wake of this transformation, consumers are placing a premium on responsible sourcing, low carbon footprints, and a preference for plant-based ingredients. This paradigm shift in expectations signals a departure from conventional cleaning product preferences, demanding a more conscientious approach from industry leaders.

Sustainable Materials for a Greener Tomorrow

As a response to the environmental and social demands, Kao guides one of its key chemistries, ethoxylated glycerine esters, towards greener and more performing materials [3-4].

These surfactants, sourced from environmentally conscious processes, not only align with responsible sourcing but also contribute to reduction of the carbon footprint - a critical factor in the current discourse on climate change.

Figure 1 illustrates the chemical structure of ethoxylated glycerine esters and their general characteristics. These non-ionic surfactants are 100% active, clear and homogeneous liquids over a wide range of temperatures, allowing cold processable energy saving during transport and handling in comparison to standard ethoxylated fatty alcohols. Thus, ethoxylated glycerine esters show a good sustainable profile according to current market requirements, being the sustainable choice for the replacement of ethoxylated fatty alcohols.

In addition, ethoxylated glycerine esters are approved by Ecocert and are also recognised as suitable ingredients for ecological labels (EU Ecolabel, Nordic Ecolabel).

Formulation Benefits Redefining Clean

Beyond their environmentally friendly profile, ethoxylated glycerine esters offer formulation benefits that redefine the concept of cleanliness, contributing to sustainability along the

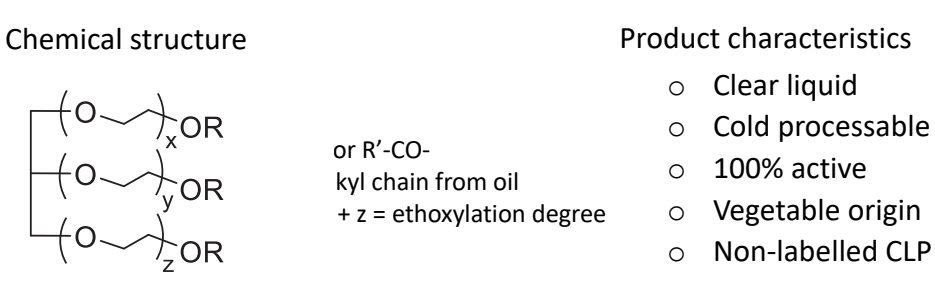

Fig. 1 General chemical structure of EO-glycerine esters, with x+y+z being the ethylene oxide moles and R=R'-CO or H, R' the alkyl chain, and the general properties shared by this surfactants family.

entire value chain, and allowing the possibility to produce green formulations. These innovative formulations not only ensure a thorough cleaning process but also introduce a level of eco-consciousness that resonates with the discerning modern consumer.

Firstly, the challenging formulation of waterless formats becomes feasible thanks to its outstanding hydrotropic ability [5]. Thus, concentrated formats not only reduce the carbon footprint during transport but also reduce the amount of packaging waste. Secondly, formulas can be designed with better eco-toxicological profiles, that reduce the human and environmental impact during and after product use.

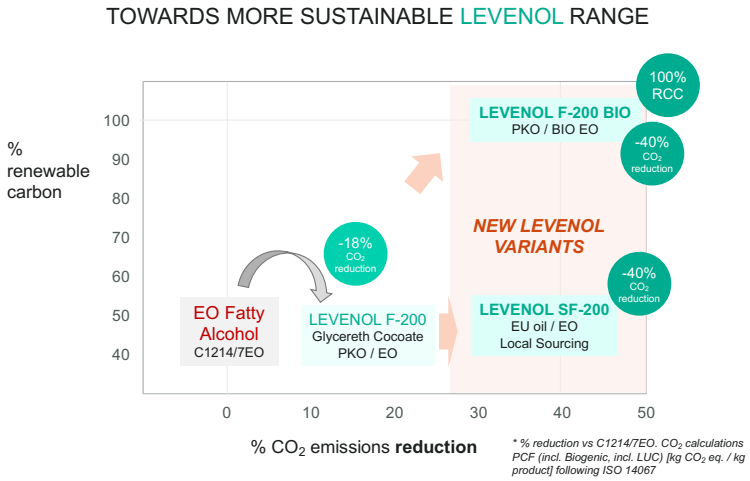

Fig. 2 Renewable carbon content and the reduction of CO_2 emissions referred to standard ethoxylated fatty alcohols. Standard and new versions of ethoxylated glycerine esters.

Usability Advantages for Eco-Conscious Choices

In an era where consumer choices are increasingly influenced by environmental considerations, the usage of a product becomes a crucial factor. The LEVENOL range, in recognising this shift, goes beyond conventional surfactants. Its usability advantages extend to facilitating eco-conscious choices in usage patterns, emphasising the efficient and mindful use of resources.

By providing sustainable materials, introducing formulation benefits that redefine cleanliness, and offering usability advantages that align with eco-conscious choices, Kao is not just meeting consumer expectations — it is setting a new standard for responsible and sustainable home care solutions.

Towards a More Sustainable LEVENOL Range

Ethoxylated glycerine esters are obtained from an optimal manufacturing process that clearly reduces the environmental impact in comparison to standard ethoxylated fatty alcohols. **Figure 2** shows the renewable carbon content (according to standard EN 17035 [6]) and the reduction of CO_2 emissions referred to standard ethoxylated fatty alcohols (according to ISO 14067 [7]). The standard ethoxylated glycerine ester, LEVENOL F-200 from palm kernel oil (chemical description glycereth-6 cocoate), reduces the carbon footprint by around 18%.

Considering the current and challenging market environment, Kao has even gone a step further in the sustainable profile of this product range. New versions of ethoxylated glycerine esters have been developed: 100% Bio-based (LEVENOL F-200 BIO glycereth-6 cocoate) or palm-free from local sourcing (LEVENOL SF-200 glycereth-6 sunflowerate and EMANON XLF BIO glycereth-7 caprylate/caprate). These versions afford a 40% reduction in the carbon footprint in comparison to ethoxylated fatty alcohols, which significantly increases the sustainable profile of the final compositions.

LEVENOL F-200 BIO – 100% Bio-Based – Non-GMO Version

Looking for a more sustainable range, a version of an ethoxylated glycerine ester from 100% Bio-based – non-GMO ethylene oxide has been developed: glycereth-6 cocoate bio (LEVENOL F-200 BIO). This product definition maintains product characteristics and features from the standard version, with a lower content of 1,4-dioxane (< 1 ppm) achieved through an improvement in the production process.

Glycereth-6 cocoate bio represents a useful tool for designing 100% bio-based compositions covering different application fields: liquid laundry detergents, hand-dishwashing and neutral hard surface cleaners.

A 100% bio-based composition to be used as liquid laundry detergent is shown in **Figure 3**, demonstrating detergency efficacy equivalent to that of European market references with a high content of natural ingredients [8].

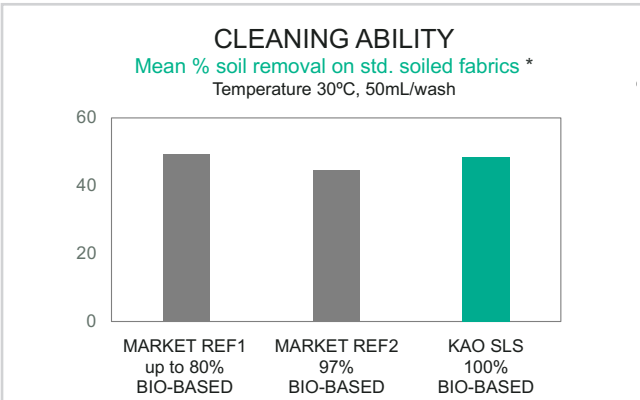

Fig. 3 Cleaning ability versus market references – Mean % soil removal on standard soiled fabrics (refs E101, E104, E112, E114, E116, E117, E160, E164, wfk10D, wfk20D, wfk10TE, wfk10SG). KAO D-316 composition: 20% active (SLS 10.0%, LEVENOL F-200 BIO 7.0%, 3.0% potassium oleate, ICTEOL K-50-E), 2.0% sodium citrate, minor ingredients (electrolytes, enzymes…), water up to 100%.

Cleaner, Greener Approach to Neutral Cleaners

The attributes of glycereth-6 cocoate bio extend beyond its role in formulating bio-based neutral cleaners, providing a comprehensive and sustainable solution for cleaning needs.

The remarkable characteristic of low residues on surfaces underscores its effectiveness, promoting a cleaner, greener and more sustainable approach to neutral cleaning, catering to the evolving preferences of environmentally conscious consumers [9].

EMANON XLF BIO – 100% Bio-Based – Non-GMO Version

Adding to the bio-based range, EMANON XLF BIO (glycereth-7 caprylate/caprate bio) enters the scene offering another dimension to Kao's commitment to sustainability. This 100% bio-based ingredient is the ethoxylated glycerine ester from Caprylic/Capric Triglyceride, and it is also available in Personal Care quality under the trade name of EMANON EV-E BIO.

With a very low 1,4-dioxane level (< 1ppm) and an improved carbon footprint, this product exemplifies ease of use through its non-ionic character, vegetable origin and suitability for Ecolabel.

Not only does glycereth-7 caprylate/caprate bio exhibit good foaming ability in the presence of soil, making it suitable for applications such as hand-dishwashing soaps (**Figure 4** [10]), but it also showcases an outstanding hydrotropic ability, simplifying the formulation of concentrated detergents [11].

Beyond Standard Formulations: Solvent-Free, Ultra-High Bio-Based Concentrates

Waterless formats or concentrates are perfectly aligned with current market trends in terms of sustainability, allowing the possibility to reduce emissions during transport and also waste. These compositions are challenging from the formulation point of view, since they contain a high content of surfactants and a low content of water. So, in this formulation environment, formula feasibility could be compromised, making the compatibility of all formula ingredients difficult.

The better hydrotropic properties of glycereth-6 cocoate bio in comparison to typical non-ionic surfactants allows the formulation of concentrates for laundry with less or even no use of additional solvents, resulting in well balanced cost-effectiveness.

Up to 96% bio-based, solvent-free, ultra-high laundry concentrates that are ready-to-use ideal formulas for control dosing dispensers could be formulated using glycereth-6 cocoate bio. The equivalent compositions using standard ethoxylated fatty alcohols are not feasible **(Figure 5)**.

The presence of glycereth-6 cocoate bio also makes it easy to formulate high bio-based liquid laundry tablets, also a

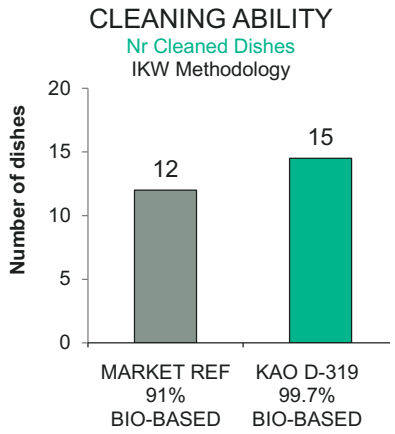

Fig. 4 Cleaning ability versus market references – Number of clean dishes by hand following the IKW method KAO D-319 composition: 18% active (SLS 12.0%, cocoamidopropyl amine oxide 6.0%, EMANON XLF BIO 2.0%), 2.0% ethanol, water up to 100%.

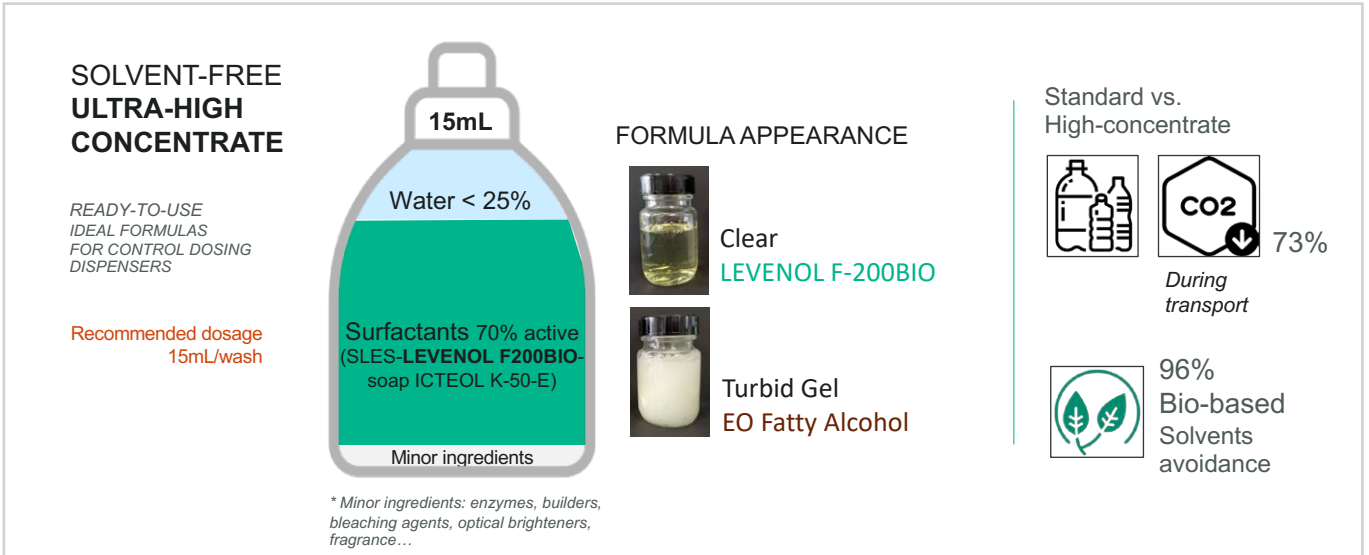

Fig. 5 A high bio-based content, solvent-free, ultra-high laundry concentrates using glycereth-6 cocoate bio (LEVENOL F-200 BIO).

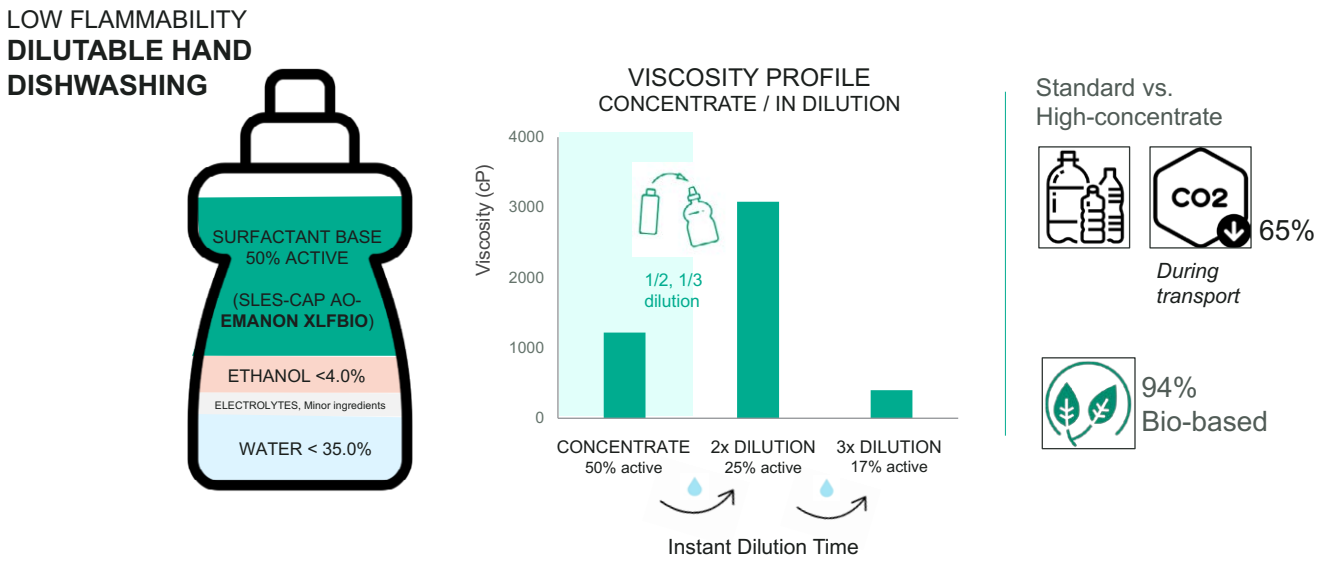

Fig. 6 A high Bio-based content, low flammable dilutable hand dishwashing using glycereth-7 caprylate/caprate Bio (EMANON XLF BIO)

high-concentrate composition around 65% active, containing less than 10% of water to ensure stability of the hydrosoluble film and a high content of non-aqueous solvent. The good hydrotropic ability of LEVENOL F-200 BIO allows feasible compositions only using glycerine as solvent. Also in this case, the same composition using EO fatty alcohols is not feasible [12].

Another example of both waterless dilutable and bio-based compositions can also be applied to the hand dishwashing application, using glycereth-7 caprylate/caprate bio (EMANON XLF BIO) [13]. Low flammable compositions with high active matter content (around 50% active with less than 4.0% ethanol) and with a suitable viscosity profile both in concentrate and in dilution, as shown in **Figure 6**, are feasible using this ingredient.

A low viscosity value in concentrate, with easy dilution using tap water, and offering required viscosities in dilution, could be achieved without the addition of any thickener. This composition also contains a high bio-based content, decreasing the plastic and CO_2 emissions during transport by around 65%.

These innovative approaches not only illustrate Kao's commitment to sustainability but also ensure suitability for EU Ecolabel certification.

LEVENOL SF-200 – Palm-Free / European Local Sourcing

LEVENOL SF-200 (glycereth-6 sunflowerate), sourced locally in the European Union, introduces palm-free alternatives to a wide range of applications, emphasising fabric care properties to redefine the standards of textile maintenance and cleanliness. This is a 100% active ingredient, showing a clear, homogeneous and liquid appearance, which makes it cold processable. Furthermore, it shows a good eco-toxicological and sustainable profile: non-labelled under CLP, low 1,4-dioxane content (< 1 ppm), and an improved carbon footprint.

The introduction of glycereth-6 sunflowerate in liquid laundry detergents not only maintains the effectiveness of standard derivatives from medium alkyl chains, but also provides a tangible benefit on the fabric, as shown in **Figure 7**.

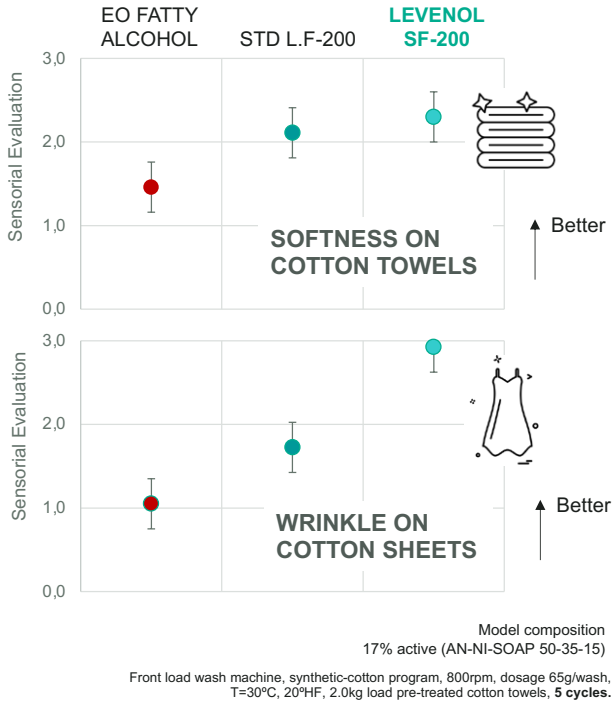

Fig. 7 Fabric care properties (softening effect on cotton towels and presence of wrinkles on cotton sheets). Comparison between laundry compositions using ethoxylated fatty alcohols, standard glycereth-6 cocoate (LEVENOL F-200) and glycereth-6 sunflowerate (LEVENOL SF-200).

Users can anticipate a marked improvement in fabric softness, particularly noticeable in the gentle touch of cotton towels. Moreover, its innovative formulation contributes to better wrinkle outcomes on cotton sheets, ensuring that fabrics not only retain their structural integrity but also deliver enhanced comfort and aesthetics. This dual benefit in fabric care positions LEVENOL SF-200 as a pivotal choice for those who prioritise not only sustainability but also superior performance in textile maintenance.

Conclusions

In the ever-evolving landscape of sustainable chemical solutions, Kao Chemicals demonstrates its commitment to environmental stewardship through its ethoxylated glycerine ester range (LEVENOL). This transformative journey from conventional to bio-based and palm-free versions represents not just a product evolution but also a profound shift towards a greener future. The clear reduction of CO_2 emissions versus ethoxylated fatty alcohols (around 40%) could be a powerful tool for the design of formulations with an improved sustainable profile.

In addition, the new versions maintain the multifunctionality of ethoxylated glycerine esters, making it easy to formulate concentrates and super-concentrates, as well as contributing to the final performance.
Lastly, by achieving a better ecotoxicological profile, higher bio-based content, and ECOLABEL suitability across various products, Kao aligns its offerings with globally recognised standards for ecological excellence. This not only enhances the marketability of its products but also signifies a dedication to meeting or exceeding stringent environmental benchmarks.

As Kao Chemicals steers towards a future where clean and green coalesce seamlessly, its LEVENOL range emerges not just as a product line but also as a symbol of responsible innovation. The reduction in carbon footprint, innovative formulations, EU local sourcing, and the multifunctionality of these bio-based solutions altogether show Kao's commitment to sustainability.

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