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Introduction

Consumers today are increasingly aware of the responsibility to themselves and the environment in the selection of the cleaning products that they use in their homes.

A move towards low toxicity, sustainably sourced formulations is already happening, supported by third party certifiers such as the Roundtable on Sustainable Palm Oil (RSPO) and EU Ecolabel, who are creating an aspiration and recognition of more sustainable cleaning products with consumers.

This trend will continue to accelerate, necessitating as it does, innovation and reformulation that delivers on consumer demand for high performance cleaning, whilst minimizing the impact on the environment.

Consumer Demand Leading Change

Consumers' heightened awareness of the impact of cleaning products in the home is radically reshaping the design of products today and their associated supply chains. The consumer expects no sacrifice in performance, whilst they aspire to use low toxicity products that create a safe home, are safe to handle and are safe for the environment. In addition, they increasingly want those products to be sustainably sourced, from natural vegetable origins, with a supply chain that has minimal impact on the environment. And for this, the consumer is prepared to pay a premium. Many of the critical ingredients in high performance cleaning formulations today have historically been sourced from unsustainable, fossil fuel derived raw materials. Others may come from renewable animal sources, but the sustainability element of such origins is also a question. However, their use continues for a variety of reasons, including cost, availability and performance.

Transparency in Labelling and Third-party Certifications

In the past, it had been difficult for consumers to find out whether their cleaning product contained sustainably sourced ingredients. This is changing today with the appearance of:

- Marketing claims voluntarily used by producers on product packaging
- Independent third-party assessment of cleaning product sustainability according to published criteria – EU Ecolabel, Nordic Swan etc.

- Certification of sustainable supply chain origin – RSPO, EcoCert etc.

A greater transparency in the ingredient labelling for cleaning products is coming. As an example, regulations will soon come into effect in California, as part of the Cleaning Products Right to Know Act, which will mandate full ingredient disclosure on product labels, like that which you see on food packaging today, with additional impurity disclosure on a website hosted by the seller. If this trend continues, it is very possible for this mandate to gain momentum in Europe too. As such, a clear drive for the industry will be to develop high-performance, more sustainable cleaning product ingredients, in advance of this trend becoming more mainstream.

Partnering for a More Sustainable Future

Green chemistry and sustainable sourcing have been key practice areas for Nouryon for decades and continue to be major factors in driving our innovation pipeline for the cleaning industry. Formerly as AkzoNobel Specialty Chemicals, and thereby as AkzoNobel, the company has ranked in the top three in the chemicals sector of the Dow Jones Sustainability Index for the last 10 years. While the company bears a new name and brand, Nouryon is still the same trusted partner that views sustainability as a true business opportunity that delivers value to everyone involved.

Evidence of this commitment has been its early membership of RSPO and Nouryon's broad portfolio of EU Ecolabel compliant products being offered today.

Roundtable on Sustainable Palm Oil (RSPO)

One of the earliest developments in certification of sustainable supply chains was initiated in 2004 with the founding of the Roundtable on Sustainable Palm Oil (www.rspo.org). To counter concerns regarding the environmental and human impact of the palm oil industry, this organization was established to bring together stakeholders from across the industry, including growers, processors, consumers, environmental groups and more, with the goal of creating a system of governance and traceability for palm oil (and its derivatives) that is grown in a sustainable manner – a supply chain mod-

el that until today remains unmatched. Although palm oil is primarily used as a foodstuff, rather than as a chemical feedstock, palm kernel oil (PKO), along with coconut oil, remain the only viable commercial sources of biobased low/medium carbon chain length (C6-14) oils, which find particular utility as ingredients in cleaning formulations. Although coconut oil and PKO share many similar characteristics, coconut oil has historically been costlier, with tighter supply, and as such, PKO is often the raw material of choice for industrial consumption.

EU Ecolabel – Promoting the Adoption of RSPO

A key driver in Europe for the adoption of RSPO-certified raw materials has been the recent revision of the EU Ecolabel requirements for third-party cleaning product formulation certification. In the most recent revision to its standards – fully implemented June 30, 2019, the EU Ecolabel authorities mandated that all palm oil derived ingredients must be RSPO-certified to qualify the vendor to use the EU Ecolabel, which was not the case previously. The authorities have favored RSPO-certified products, based on the enhanced sustainability of the RSPO accredited supply chain.

The EU Ecolabel is one of environmental excellence that is awarded to products and services meeting high environmental standards throughout their life-cycle – from raw materials extraction, to production, distribution and disposal. The accreditation scheme allows cleaning products that meet its stringent criteria to use the EU Ecolabel brand on their product labels. By their own admission, no more than 10-20 percent of the most environmentally performing products should qualify for this standard, thus maintaining the relevance to EU citizens in choosing greener products. This cobranding strategy, using the EU Ecolabel's well-established trademark, has good consumer recognition, and acts as clear guidance to consumers who are interested in making the choice to buy more sustainable cleaning products – even if the average consumer may not fully appreciate the specifics of what qualifies for the use of the trademark.

The enhanced demand from the recent Ecolabel criteria change did not significantly challenge the global RSPO supply chain, as the adoption of Ecolabel remains quite niche. However, as adoption of RSPO-certified raw materials becomes more mainstream, the price premium for RSPO-certified feedstocks may become larger as demand outstrips finite supply. According to RSPO's own data, from the total ca. 65M mT/a of palm oil produced globally (2017), RSPO accounts for only 19 percent of this output. Although RSPO demand from the chemical industry remains a relatively small portion of the overall demand, it is conceivable that certain RSPO-certified PKO fractions may become

supply-challenged as sustainable cleaning products become more mainstream, and potentially even more costly.

Transformation of the Cleaning Industry – Moving from Synthetic to Natural Feedstocks

RSPO and EU Ecolabel are at the vanguard of leading the cleaning industry to responsibly transition away from synthetic, hydrocarbon-based raw materials towards natural, renewable feedstocks. However, it should also be recognized that synthetic materials do have certain unique technical or performance advantages that means there will likely always be a place in the market for these ingredients.

It is also important to note that rerouting raw material demand to come from natural sources should not be to the detriment of the environment or human health and wellbeing. For example, if industrial demand for raw materials comes at the expense of someone sourcing food for themselves and their family. Responsible management of this transition is therefore industry's shared responsibility.

No Need to Sacrifice Performance

One of the questions that consumers often ask is whether the use of more sustainably sourced ingredients will reduce the overall performance of cleaning products. Although it is a specific case, a performance-in-use comparison was recently made between two primary surfactant cleaning ingredients:

- Product A – a synthetically sourced, lightly branched C9-11 alcohol, ethoxylated with 4EO
- Product B – a naturally sourced (RSPO), linear C10 alcohol, ethoxylated with 4EO (Berol 360)

Obviously, product B is the more sustainable option in this case. In **Fig. 1**, we show the black box test results comparing 5% non-ionic primary surfactant products A + B when incorporated into a simple framework cleaning formulation at two dilu-



Fig. 1 Black box cleaning test on a ceramic tile soiled with used cooking grease and aged for 5 hours at 60°C.

tions – 1/10 and 1/40. The performance of the two solutions in this study is identical. Furthermore, the physicochemical properties of the two materials are also the same.

What that means in this case is that the more sustainable Product B (Berol 360) can be dropped into a product to replace Product A with no noticeable difference in performance, with no need for reformulation, saving the expense of lab time in development.

Although the hydrophobes in A and B are not quite identical in this case, it should be noted that like-for-like, synthetic vs. natural origin materials will perform identically.

When a direct drop-in is not available for a particular formulation chassis, a radically alternative chemistry may need to be considered. In such cases, compromise may be required in certain areas, with the consideration of what's critical to the consumer likely determining the final selection.

High Performance Ingredients are Already Available Today

With the above surfactant ingredient example, the focus for enhanced biobased content of the surfactant has been associated with the hydrophobe. However, we should not ignore that enhancing the biobased content of surfactant hydrophile is also advantageous. Ethylene oxide (EO) based nonionic surfactants today are largely built on fossil fuel sources (though costlier green EO is available in limited commercial quantities). Beyond EO, significant work has already been undertaken by this company (and others) to find alternative nonionic biobased hydrophiles. Alkylglucosides, such as AG6206 – available from Nouryon, offer current commercial solutions, offering the formulator interesting performance features, along with the enhanced environmental performance and elevated bio-based content.

Other important cleaning ingredient classes that have traditionally been synthetically derived are as follows, with their more sustainable and/or higher biobased variants described:

- Synthetic water-soluble polymers used broadly in laundry and ADW formulations as builders/anti-scalents today are predominantly synthetically based
 - Functional replacements include readily biodegradable hybrid polymers, composed mostly of natural raw materials (Alcoguard H5941)
- Hydrotropes (such as SXS and SCS), which today are derived from fossil origins
 - Functional replacement which offer enhanced performance include readily biodegradable, RSPO-derived Berol R648 PO
- Synthetic chelants (such as EDTA) are used across many cleaning formulations today and are also largely fossil fuel-derived (and no longer Ecolabel compliant).
 - Functional replacements include products derived from biobased L-glutamic acid (Dissolvine GL)
- Biocides (such as BHT) are largely synthetically derived today
 - Largely biobased alternatives such as Triameen Y12D and Arquad MCB-50 PO are available as alternatives today

With the exception of the two biocides, all of the more sustainable products mentioned above are EU Ecolabel compliant ingredients.

Transformational Next Generation Formulations

Overall, the growth of the sustainable cleaning market in Europe has been slow to develop with minimal holistic reformulation work undertaken with most of the focus being on identifying drop-in replacements for current chassis formulations. The next step in development, and true maturation of the market, will be a root-and-branch reconsideration of formulations with sustainability as a top priority deliverable.

Looking at the EU Ecolabel's most recent registry of cleaning products (March 2019), the real focus of Ecolabel innovation has been around hard surface cleaning. This area has by far the greatest number of Ecolabel-registered formulations – 3,873 in total – with hand dishwash coming in a distant second with 479 registered formulations.

Below, we present an example of a hard surface cleaner (Formulation C) that has been radically reengineered to maximize the natural components in its formulation. The components still remain fairly typical – a primary surfactant using an RSPO hydrophobe (vs. synthetic), a naturally derived chelant using L-glutamic acid as its starting material (vs. fossil-derived EDTA) and a hydrotrope based on RSPO-certified raw materials, comparing with synthetic xylene sulfonates. It should be noted that the activity of the natural Formulation C is significantly lower than the synthetic Formulation D, which is enabled by optimization and synergies between the ingredients. This also puts a lower burden on the environment when the natural formulation is released after use. Note that Formulation C would qualify for EU Ecolabel whereas Formulation D would not.

Natural Based – Formulation C:

- 5% Berol 360
- 7% Dissolvine GL-47-S
- 2.8% Berol R648 PO

Fossil Based – Formulation D:

- 5% Berol 260
- 7% EDTA
- 10% SXS

Formulation D is representative of hard surface cleaner formulations used today.

The black box cleaning data shown in **Fig. 2** also clearly demonstrates that the natural formulation significantly out-competes the fossil version, even with significantly higher dilution. Taking both the lower activity and enhanced dilutions that can be achieved, Formulation C is not just favorable in terms of natural content and EU Ecolabel compliance, but is also most cost-effective too.

The maturation of the market to focus on sustainability as a

key performance indicator in formulation development will bring in a wide variety of new chemistries and functionalities that may not be so prominent in the market today but can compete with existing technologies on overall cost/performance. Nouryon stands in support of these developments through its ongoing innovations and commitments to growing the sustainable solutions available to the cleaning industry. EU Ecolabel will continue to evolve and update their guidelines to reflect this maturity and encourage cutting-edge sustainability in products seeking EU Ecolabel cobranding.

Conclusions

More sustainable cleaning formulations are taking a prominent position in the European consumer cleaning market,

encouraged by formulators cobranding with 3rd party certifiers, such as RSPO and EU Ecolabel. Whilst the demand for such products remains niche today, adoption by a small but important and growing group of enthusiastic consumers continues to gather pace; a group prepared to pay a premium for such solutions.

As this trend becomes more mainstream with time, a fundamental rethink of ingredient chemistry will be required to fully benefit from the sustainable solutions offered, with radical reformulations likely – something that may create its own challenges in supply chains and finite quantities of RSPO-certified raw materials.

Continuing evolution of the 3rd party certifiers standards will provide opportunity for continued ingredient innovation, so that the highest environmental standards in sustainable consumer cleaning can be maintained. Nouryon will continue its journey in support of the industry, committed to realizing more sustainable chemistry for the cleaning market, today and in the future.

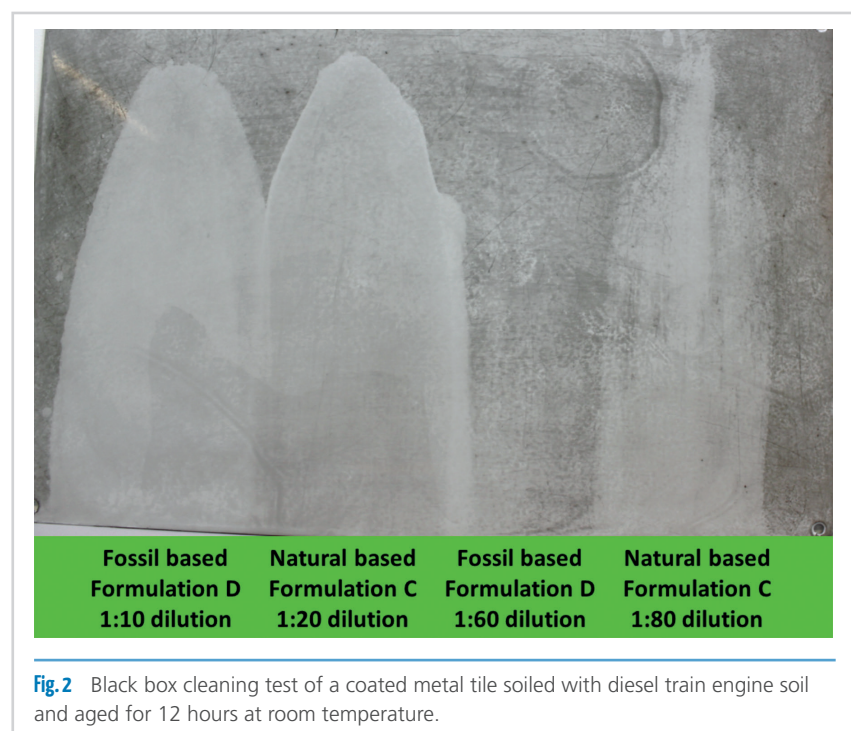


Fig. 2 Black box cleaning test of a coated metal tile soiled with diesel train engine soil and aged for 12 hours at room temperature.

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