SOFT-N-SAFE™ – a sustainable alternative to fossil-based plasticisers

Polymers can gain unique sustainability benefits from SOFT-N-SAFE™, our castor oil-based plasticiser for PVC and several other key polymers. Its easy processing characteristics and extremely low emissions of volatile organic compounds make it a natural choice for PVC converters. For brand-owners who value its global regulatory and excellent safety profile, it holds great appeal.

This paper documents the findings of an independent LCA, demonstrating the potential of SOFT-N-SAFE™ as a low-impact alternative to petroleum-based products with notable benefits in several key areas.

Covering all life cycle stages from raw material cultivation to dispatch of the final product from our factory, the assessment has been conducted in line with the ISO 14040 and 14044 standards and, importantly, the first edition of the International Reference Life Cycle Data System (ILCD) Handbook from the EU Joint Research Centre. The assessment includes 18 impact categories and demonstrates that the environmental burdens associated with the use of SOFT-N-SAFE™ are modest and characterised by:

- Low contribution to global warming
- Low fossil depletion
- Low water depletion

The LCA shows that SOFT-N-SAFE™ offers unparalleled advantages throughout its life cycle: from enhancing the appeal of polymer products to ensuring a higher residual value at the end of life stage.

This document explains how the use of SOFT-N-SAFE™ can be a key differentiator for customers within the polymer industry – meeting both regulatory requirements and consumer demand for more natural, sustainable products.
I. Assessing the sustainability of SOFT-N-SAFE™ production in detail

The LCA was completed by 2-0 LCA Consultants in 2011 in accordance with the ISO 14040 and 14044 standards. The external review was completed by FORCE Technology, Denmark.

1.1 Functional unit and scope
The LCA focuses on the cradle-to-gate impacts associated with the production of 1kg of SOFT-N-SAFE™ dispatched from Danisco’s factory in Grindsted, Denmark – taking into account the resource inputs and emissions and the potential environmental burden in relation to 18 impact categories.

The study does not address the safety profile when the material is in direct contact with humans. This is the subject of independent extensive testing at Danisco and can be accessed by contacting our Polymer Additives department directly.

It is important to highlight that an LCA of fossil-based plasticisers, consistent with the methodology applied in this study of SOFT-N-SAFE™, is necessary for any comparison to be made.

1.2 What is SOFT-N-SAFE™?
SOFT-N-SAFE™ is a novel, fully acetylated monoglyceride based on fully hydrogenated castor oil, glycerine and acetic acid. In its production, the same principles are applied as for standard acetylated mono- and diglyceride products that are globally approved as direct food additives. Hydrogenated castor oil is esterified with excess glycerine and the resulting mixture distilled to create a product that typically contains 95-96% monoglyceride. The free hydroxyl groups on the monoglyceride are then esterified with acetic acid. The two main components of SOFT-N-SAFE™ represent around 95% of its total composition (figure 1).

1.3 Production of SOFT-N-SAFE™
Figure 2 shows the process flow for SOFT-N-SAFE™.
The life cycle begins with the cultivation of castor plants in the western part of India, the world’s largest producer of castor oil. The beans containing the oil grow on castor oil plants, which are perennial and can reach the size of a small tree. However, in the cultivation system for castor beans, the castor plant is harvested on an annual basis. The seeds largely comprise of triglycerides and are mainly harvested by machine, which also removes the stem and shells, leaving them in the fields.

After harvesting, the seeds are transported to an extraction plant, typically not far from the plantations, where the castor oil and meal are extracted in an operation that involves crushing, filtration and extraction of remaining oil from the meal with hexane. Most of the meal is used as a fertiliser, but some is used as biomass for producing the heat energy required for the extraction process.

The extracted oil is then transported to the hydrogenation plant, also in India, where it is treated with hydrogen (H\textsubscript{2}). The hydrogenated oil is subsequently shipped to Denmark for processing into SOFT-N-SAFE\textsuperscript{TM}. There are two main processes. The first is ‘trans-esterification’, which is a treatment of the hydrogenated castor oil with glycerol to produce monoglyceride. The second process is a reaction between the monoglyceride and acetic anhydride. The acetylated monoglyceride that results is the end-product SOFT-N-SAFE\textsuperscript{TM}.

1.4 Excluded data and processes
As is usual in an LCA, some aspects within the set boundaries are excluded due to redundancy or statistical insignificance. The scope and boundaries for this study excluded the impact of human activities, such as travel to and from work. It also excludes services such as marketing, accountancy, consultants, business travelling and financial intermediation.

1.5 Other methodological issues
The Ecoinvent database uses allocation between co-products which do not comply with the preferred method for handling of co-product allocation according to the ISO 14044 standard as well as the ILCD Handbook. It has been assessed that this, however, does not have any significant impact on the results as the most important activities do not involve co-products.
2. Results

The LCA clearly indicates that SOFT-N-SAFE™ has a particularly low environmental impact, suggesting that the product’s contribution to global warming is similar to or even less than that of the polymer in which it is most often used (see section 3).

It should be stressed that the LCA study is based on state-of-the-art data covering the entire life cycle, including castor oil cultivation in India. A conservative estimate has been applied in a number of cases. In spite of the uncertainties and limitations associated with LCA as a methodology, it is reasonable to conclude that the production of SOFT-N-SAFE™ has a low environmental impact from cradle-to-gate. The complete list of impact categories, according to the ReCiPe LCIA method, are illustrated in figure 3.

At Danisco, we regard the LCA as a significant tool for identifying ‘hot spots’ to help us improve our performance over time. As such, it is a source of information that can help direct our continuous improvement programmes.

It should be stressed that this study applies attributional modelling in accordance with the requirements of the ILCD Handbook from the EU Joint Research Centre. However, a sensitivity scenario, based on consequential modelling, has also been developed as part of the study. In this scenario the carbon footprint falls more than 20%.

3. What does this mean?

The LCA is non-comparative and no comparisons have been made with other similar products, e.g. fossil-based plasticizers. Such a comparison would require that the exact same modelling approach be applied and would entail a panel review. However, to illustrate the magnitude of the results, we have made a rough comparison to other types of non-competing products.

According to Plastics Europe, the carbon footprint of E-PVC, S-PVC and PET is 2.5, 1.9 and 2.2kg CO₂ equivalents per kg material (cradle-to-gate), respectively. These numbers are only a rough indicator; as there may be significant differences in methodological choices between our study and the studies provided by Plastics Europe. The environmental product declarations are available at http://www.plasticseurope.org/plastics-sustainability/life-cycle-thinking/epd-reports.aspx

As SOFT-N-SAFE™ is based on Danisco’s food ingredient technology, we have also compared its carbon footprint with that of several food items to provide a sense of magnitude. If we take dairy products as an example, milk typically has a carbon footprint of around 1kg CO₂ equivalents per litre finished product, while cheese represents around 10kg CO₂ equivalents per kg. This means that the emissions from the production of 1kg SOFT-N-SAFE™ are equivalent to that of 2 litres of milk or approximately 200g of cheese.

<table>
<thead>
<tr>
<th>Impact category</th>
<th>Unit</th>
<th>Baseline result</th>
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<tbody>
<tr>
<td>Climate change</td>
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<td>Ozone depletion</td>
<td>kg CFC-11 eq</td>
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<td>Human toxicity</td>
<td>kg 1,4-DB eq</td>
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<td>Photochemical oxidant formation</td>
<td>kg NMVOC</td>
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<td>Particulate matter formation</td>
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<tr>
<td>Ionizing radiation</td>
<td>kg U235 eq</td>
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<td>Marine eutrophication</td>
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<td>Terrestrial ecotoxicity</td>
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<td>Fossil depletion</td>
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</table>
4. Regulatory status

SOFT-N-SAFE™ is widely approved for use in food contact plastics around the world – SOFT-N-SAFE™ is REACH registered.

SOFT-N-SAFE™ is approved for use in food contact materials as follows:

EU – SOFT-N-SAFE™ is approved for use in plastics without restrictions or a specific migration limit (SML) and only the generic SML of 60 mg/kg applies. The product is approved according to Commission Regulation (EU) No 10/2011 and has the packaging material ref. no. 55910.

USA – FDA has approved the use of SOFT-N-SAFE™ in cap sealing rings and articles intended for repeated contact with all foods, and as a colorant carrier/dispersant for use in polymeric food packaging. Reference FCN 750 and FCN 812.

Mercosur – SOFT-N-SAFE™ is approved for use in food contact materials without restrictions, according to resolución-rdc No 17, de 17 de Marco de 2008.

China – SOFT-N-SAFE™ is approved for food contact materials without restrictions, according to GB9685-2008 “Hygienic standard for uses of additives in food containers and packaging materials”.

Japan – SOFT-N-SAFE™ is accepted for use in food contact materials according to industry standards.

Registered new chemical
SOFT-N-SAFE™ is registered as a new chemical in the following regions and is accepted for use in applications that do not require specific approval:

Switzerland (BAG), USA (TSCA), Canada (DSL), China (IECSC), Japan (ENCS-METI), South Korea (ECL-TCCL), Brazil, Australia (AICS).

5. A more sustainable solution for customers and consumers

Overall, this study demonstrates the minimal impact of SOFT-N-SAFE™ on our environment.

This LCA is both an assessment of the current position and a tool to shine a spotlight on opportunities for further improvement.

For more information, please visit www.danisco-polymeradditives.com.