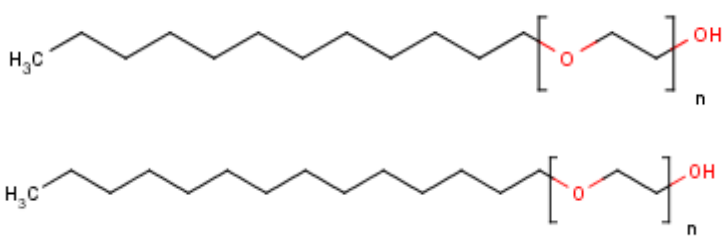
Date: 02/06/2017

Environmental Fact Sheet (#9)

C12-14 Alcohol Ethoxylates (3EO) (C12-14 AE3)

oleochemical non-ionic surfactant

Substance Identification			
IUPAC Name	Alcohols, C12-14 (even numbered), ethoxylated	**CAS Number**	68439-50-9
Other Names	Lauryl Alcohol Ethoxylate		
Molecular Formula	UVCB substance (substances of Unknown or Variable composition, Complex reaction products or Biological materials), no univocal molecular formula available	Structural formula: 	

Physical/Chemical Properties [1,2]	
Molecular Weight	318.49 – 346.54 g/mol
Physical state	Liquid
Appearance	Colourless, homogenous and opaque
Odour	Slight characteristic
Density	0.9 g/cm^3 at 20°C (proxy from C12-14 AE2)
Melting Points	18 - 27 °C
Boiling point	< 181 °C at 0.5 mmHg
Flash Point	149 °C at 101.4 kPa (proxy from Alcohol C12-14, ethoxylated (1-2.5 EO))
Vapour Pressure	0.014 – 0.11 at 25°C
Water Solubility	11 mg/l at 25°C
Flammability	No data available
Explosive Properties	No data available
Surface Tension	27 mN/m at 20°C (proxy from C12-14 AE2)
Octanol/water Partition coefficient (Kow)	log K_{OW} = 5.03 – 6.11
Product and Process Description	C12-14 AE3 is a non-ionic surfactant, belonging to the group of alcohol ethoxylates, with 3 moles of ethylene oxide. The alcohol ethoxylates with three ethylene oxide units are produced by the reaction of C12-C14 fatty alcohols (oleo) with ethylene oxide. The addition of ethylene oxide to C12-14 fatty alcohols leads to a distribution of homologue polyethylene glycol ether groups. The ethoxylation reaction can be catalyzed by alkaline catalysts as e.g. potassium hydroxide or by acidic catalysts as e.g. boron trifluoride or zinc chloride. For detergent range alcohol ethoxylates, the alkaline catalysis is normally used. The intermediate ethylene oxide is industrially produced by direct oxidation of ethylene in the

	presence of silver catalyst (Further details of the ethylene oxide production are explained in the Fact Sheet of the precursor ethylene oxide (#8)).
Application	Personal Care: Surfactant, solubilizer and foaming Agent in Shampoos and Bath Gels. Detergents: Surfactant, solubilizer and wetting Agent in Detergents, Laundry Pre-spotters and Hard Surface Cleaners. Surfactants and Esters: Surfactant Intermediate, Sulfonated to Make SLES (Sodium Lauryl Ether Sulfate). Used both in household and industrial products. Textiles: Wetting Agent in Textile and Leather Processing. Agrichemical formulations: Emulsifier

Life Cycle Assessment

General Introduction

These Environmental Fact Sheets are a product of the *ERASM Surfactant Life Cycle & Ecofootprinting (SLE*) project. The objective of this project was to establish or update the current environmental profile of 15 surfactants and 17 precursors, taking into consideration actual surfactant production technology and consistent high quality background data.

The Fact Sheets are based upon life cycle assessment (LCA) and have been prepared in accordance with the ISO standard [ISO 14040: 2006 and ISO 14044: 2006]. In addition, the project follows the ILCD (2010) handbook. This Fact Sheet describes the cradle-to-gate production for C12-14 AE3. C12-14 AE3 is an oleochemical surfactant.

The ERASM SLE project recommends to use the data provided in a full 'cradle-to-grave' life cycle context of the surfactant in a real application.

Further information on the ERASM SLE project and the source of these datasets can be found in [3].

The full LCI can be accessed via www.erasm.org or via http://lcdn.thinkstep.com/Node/

Goal and Scope of ERASM SLE Project [3]

The main goal was to update the existing LCI inventories [4,6] for the production of C12-14 AE3 and its main precursors/intermediates.

Temporal Coverage	Data collected represents a 12 month averages of C12-14 AE3 production in the year 2011, to compensate seasonal influence of data. The dataset is considered to be valid until substantial technological changes in the production chain occur.
Geographical Coverage	Current data were based on three suppliers representing C12-14 AE3 production in Europe. The geographical representativeness for C12-14 AE3 was considered 'good'.
Technological Coverage	The technological representativeness for C12-14 AE3 was considered 'good'. Figure 1 provides a schematic overview of the production process of C12-14 AE3.
Representativeness for market volume	>60% (Represented market volume (in mass) covered by primary data used in ERASM SLE project)
Declared Unit	In ERASM SLE project the declared unit (functional unit) and reference flow is one thousand kilogram (1000 kg) of surfactant active ingredient. This was the reference unit also used in [4]. Functional Unit: 1 metric tonne of C12-14 AE3 100% active substance.
Cradle-to Gate System Boundaries	

Included	Excluded
Fatty alcohol C12-14 (oleo) production (this production is further explained in the Eco-Profile fact sheet of the precursor C12-14 fatty alcohol (#3))	Construction of major capital equipment (Infrastructure)
Ethylene oxide production(this production is further explained in the Eco-Profile fact sheet of	Maintenance and operation of support equipment

	the precursor ethylene oxide (#8))	
	Energy production	Human labor and employee transport
	Utilities	Packaging
	Transportation processes for the main materials	
	Water use and treatment of waste water	
	Treatment of wastes	

Assumptions and Limitations	Transportation was only considered for the main materials (covers about 95% of the mass of all inputs), other transportation was not considered.	
Cut-off Criteria [5]	No significant cut-offs were used. The LCI study included all material inputs that had a cumulative total (refers to unit process level) of at least 98% of the total mass inputs to the unit process, and included all material inputs that had a cumulative total of at least 98% of total energy inputs to the unit process. The study included any material that had environmental significance in its extraction, manufacture, use or disposal, is highly toxic, dangerous for the environment, or is classified as hazardous waste. The sum of the excluded material flows did not exceed 5% of mass, energy or environmental relevance.	
Calculation Rules	Allocation	For C12-14 AE3 production, allocation was not applied to the foreground system. However, allocation was applied for some background data (mass allocation for the renewable precursors PKO and CNO).
	Aggregated data	Vertical averaging was considered (as long as the final product was the same, different processes with common product intermediates can be aggregated in the average)

Life Cycle Inventory and Impact Assessment [3]

Based on the LCI data an environmental impact assessment was performed for the indicators Primary Energy Demand (PED) and Global Warming Potential (GWP). Other impacts may be calculated from the full LCI dataset.

Primary Energy Demand (PED): An analysis of the inventory data showed that the main contribution comes from the main raw materials C12-14 fatty alcohol and ethylene oxide. Energy contributes with less than 5% to PED. Direct process emissions, other chemicals, utilities, process waste treatment, and transport do not have relevant influence.
The alcohol ethoxylates based on fatty alcohols from natural sources have a lower primary energy demand compared to those based on petrochemical feedstock.

Global Warming Potential (GWP): An analysis of the inventory data showed that the main contribution comes from the main raw materials C12-14 fatty alcohol and ethylene oxide. E nergy contributes with less than 5% to the GWP. Direct process emissions, other chemicals, utilities, process waste treatment, and transport do not have relevant influence. The alcohol ethoxylates based on fatty alcohols from natural sources have a lower global warming potential compared to those based on petrochemical feedstock.

The high value for carbon uptake of the C12-C14 alcohol ethoxylate is due to the main precursor C12-C14 fatty alcohol based on palm kernel oil and coconut oil.

Table 1. Primary Energy Demand and air emissions related to Global Warming per 1 tonne of C12-14 AE3 100% active substance

LCI result	Unit	Amount
Primary energy demand		
Primary energy demand from renewable materials (net calorific value)	MJ	28017
Primary energy demand from fossil materials (net calorific value)	MJ	31705
Primary energy demand from fossil and renewable materials (net calorific value)	MJ	59722
Air emissions related to Global Warming Potential		
Carbon uptake, biotic	kg CO_2 equiv.	-3001
Carbon dioxide, fossil	kg	1062
Carbon dioxide, biotic	kg	1341
Carbon dioxide, from land use, land use change and peat oxidation	kg	2377
Methane	kg	22.75
Nitrous oxide (laughing gas)	kg	0.59
NMVOC emissions	kg	1.99
Total GWP (according to [IPCC 2007])	*t CO_2-equiv.*	*2.52*

References for the ERASM SLE Project

Data Owner and Commissioner of the study	ERASM (Environment & Health Risk Assessment and Management). A research partnership of the Detergents and Surfactants Industries in Europe (www.erasm.org).
LCA Practitioner	thinkstep AG (www.thinkstep.com)
Reviewers	Prof. Walter Kloepffer, LCA Consult Mrs. Charlotte Petiot and Dr. Yannick Leguern, BiolS by Deloitte Dr. Yannick Schmidt (2.0 LCA Consultants)
References	[1] ECHA. http://echa.europa.eu [2] Human & Environmental Risk Assessment on ingredients of European household cleaning products - Alcohol Ethoxylates (Version 2.0, September 2009). www.heraproject.com. [3] Schowanek. D *et al*. (2017. New and Updated Life Cycle Inventories for Surfactants used in European Detergents: Summary of the ERASM Surfactant Life Cycle and Ecofootprinting Project. Int J. LCA, in press. [4] CEFIC-Franklin (1994). Resource and environmental profile analysis of petrochemical and oleo chemical surfactants produced in Europe. Phase II Final Report, Franklin Associates, LTD [5] PLASTICSEUROPE (2011). Eco-profiles and Environmental Declarations – Life Cycle Inventory (LCI) Methodology and Product Category Rules (PCR) for Uncompounded Polymer Resins and Reactive Polymer Precursors, version 2.0. [6] Schul, W. *et al*. (1995). A life-cycle inventory for the production of detergent range alcohol ethoxylates in Europe. Tenside Surf. Det. 32, 171–192.

Figure1. Production process of C12-14 AE3.