Date: 07/06/2017

Environmental Fact Sheet (#31)

AminoEthylEthanolAmine (AEEA)

petrochemical precursor

Substance Identification

IUPAC Name	2-[(2-aminoethyl)amino]ethanol	**CAS Number**	111-41-1
Other Names			
Molecular Formula	C4H12N2O	Structural formula: 	

Physical/Chemical Properties [1]

Molecular Weight	104.15 g/mol
Physical state	Liquid
Appearance	Colourless
Odour	Mild ammoniacal odour
Density	1024 kg/m³ at 25°C
Melting Points	-38°C
Boiling point	241.5°C at 1013.25 hPa
Flash Point	132°C at 1013.25 hPa
Vapour Pressure	0.01 hPa at 20 °C
Water Solubility	Soluble
Flammability	Study scientifically unjustified
Explosive Properties	No data available
Surface Tension	No data available
Octanol/water Partition coefficient (Kow)	log K_{OW} =-1.46 at 25°C
Product and Process Description	Aminoethylethanolamine (AEEA) is a precursor for the production of amphoacetates which serve as a precursor to produce amphoteric surfactants. AEEA is industrially produced in the process of the continuously hydrogenative amination of monoethylene glycol. In the reaction mixture AEEA is only yielded as a co-product of 6.8%. The residual compounds are 3.4% of diethylene triamine, 7.0% of piperazine, 51.1% of ethylenediamine, 1.7% of diethanolamine and 30.0% of monoethanolamine [5].
Application	AEEA is commonly used in the manufacture of lube oil additives, fuel additives, chelating agents, surfactants, fabric softeners and insecticides among other applications

Life Cycle Assessment

General Introduction

These Eco-profiles or 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 Eco-profiles 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 Aminoethylethanolamine (AEEA). AEEA is a petrochemical surfactant precursor.
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 [2].

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

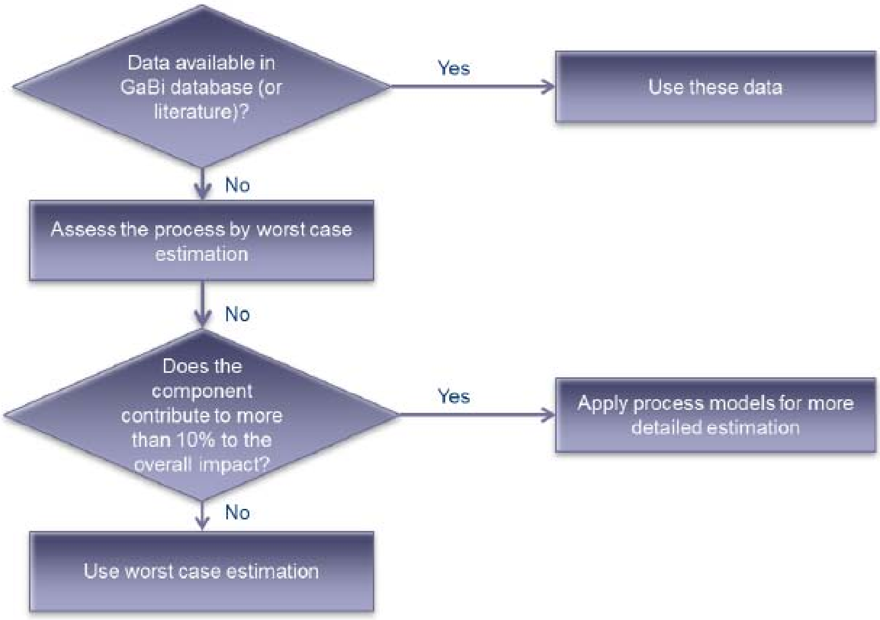
Goal and Scope of ERASM SLE Project [2]

The main goal was to update the existing LCI inventories [3] for the production of Aminoethylethanolamine.

Temporal Coverage	Data collected for AEEA production refer to literature research covering recent production technology. The reference year was set to 2011. Background data have reference years from 2008 to 2010 for electricity and thermal energy processes. The dataset is considered to be valid until substantial technological changes in the production chain occur.
Geographical Coverage	Data for AEEA came from internal database and covers European conditions. The geographical representativeness for AEEA was considered 'good'
Technological Coverage	The technological representativeness for AEEA was considered 'good'. Figure 1 provides a schematic overview of the production process of AEEA.
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 [3]. Functional Unit: 1 metric tonne of Aminoethylethanolamine 100% active substance.
Cradle-to Gate System Boundaries	(see table below)
Assumptions and Limitations	The model is based on secondary data out of patent literature. [5] In the modeling stoichiometric amounts were used because of scarce information. Only the distribution of products was taken out of the patent data. Energy as well as cooling water amounts water were estimated using different methods: extrapolation, approximation with similar chemicals, molecular structure-based models and process models following the recent production technology (cf. flowchart below).

Cradle-to Gate System Boundaries:

Included	Excluded
Ethylene glycol production	Construction of major capital equipment (Infrastructure)
Ammonia production	Maintenance and operation of support equipment
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	

<table>
<tr><td></td><td colspan="2">
</td></tr>
<tr><td>Cut-off Criteria [4]</td><td colspan="2">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.</td></tr>
<tr><td rowspan="2">Calculation Rules</td><td>Allocation</td><td>Mass allocation for 1 kg of the desired product AEEA was applied in the foreground system (AEEA is only yielded as a by-product of 6.81%. The residual compounds are 3.39% of diethylene triamine, 7.04% of piperazine, 51.1% of ethylenediamine, 1.72% of diethanolamine and 30% of monoethanolamine).</td></tr>
<tr><td>Aggregated data</td><td>From public data and literature research.</td></tr>
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Life Cycle Inventory and Impact Assessment [2]

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 shows that the PED is caused by the raw materials ethylene glycol and ammonia, representing the highest input by mass and contribute around 60% and 25% respectively to the PED. Energy sources are also significant notably: thermal energy (10%) and electricity (13%). The remaining contribution is due to electricity, direct emissions, water use, waste and waste water treatment.

Global Warming Potential (GWP): An analysis of the inventory data shows that the GWP is caused by the raw materials ethyleneglycol and ammonia, representing the highest input by mass and contribute 39% and 41% respectively to the GWP. Energy sources are also significant: thermal energy (6%) and electricity (6%). The remaining contribution is due to electricity, direct emissions, water use, waste and waste water treatment.

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

LCI result	Unit	Amount
Primary energy demand		
Primary energy demand from renewable materials (net calorific value)	MJ	2048
Primary energy demand from fossil materials (net calorific value)	MJ	64730
Primary energy demand from fossil and renewable materials (net calorific value)	MJ	66778
Air emissions related to Global Warming Potential		
Carbon uptake, biotic	kg CO_2 equiv.	-107
Carbon dioxide, fossil	kg	2564
Carbon dioxide, biotic	kg	110
Carbon dioxide, from land use, land use change and peat oxidation	kg	-
Methane	kg	7.59
Nitrous oxide (laughing gas)	kg	0.73
NMVOC emissions	kg	3.79
*Total GWP (according to [**IPCC 2007**])*	*t CO_2-equiv.*	*2.97*

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
References	[1] ECHA. http://echa.europa.eu [2] 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. [3] CEFIC-Franklin (1994). Resource and environmental profile analysis of petrochemical and oleo chemical surfactants produced in Europe. Phase II Final Report, Franklin Associates, LTD. [4] 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. [5] Van Cauwenberge *et al*. (2009). BASF SE, Method for producing ethyleneamines ethanol amines from monoethylene glycol (MEG).

Figure 1. Production process of Aminoethylethanolamine.