CHANGE REPORT

Carbon Minds database – change report

Version 2.03(2026)

carbonminds

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Version 2.03(2026), Carbon Minds

Content

1. Introduction

This document describes the Carbon Minds database changes when updating from V2.02 2024 to V2.03(2026). The document covers new features of the Carbon Minds database, as well as database-wide changes and changes in specific chemical processes. The Carbon Minds methodology document Version 2.03(2026) is the corresponding document to this change report.

All changes described in this document are adapted to the complete Carbon Minds database and its datasets in ILCD, SimaPro.CSV, and Excel data formats.

1.1 Database Version Information

Database version: V2.03(2026)
Year of database publication: 2026
Database reference year: 2024

2. New features

This chapter describes database-wide new features of the updated Carbon Minds database. This includes the updated third-party review and recertification by TÜV Rheinland Energy & Environment GmbH, the addition of renewable chemical datasets, and the integration of additional ESU-services data to the background of the Carbon Minds database. Moreover, the new online database portal is introduced, which serves as a structured interface to explore Carbon Minds datasets.

2.1 Updated third-party review and recertification

The Carbon Minds database methodology is designed to provide data for ISO 14040/14044 compliant LCA studies, ISO 14067 compliant PCF studies, PCF calculations compliant with the "Together for Sustainability" (TfS) guideline for PCF, as well as PCF calculations compliant with the "Product Life Cycle Accounting and Reporting Standard of the Greenhouse Gas" (GHG) Protocol. Moreover, the Carbon Minds database methodology is compliant with the "UEIL/ATIEL methodology for PCF calculations of lubricants and other specialities" and with guidance from the World Business Council for Sustainable Development (WBCSD).

Throughout this database update, the compliance of the methodology to generate the Carbon Minds database with the ISO standards 14040, 14044 and 14067 has once again been recertified by TÜV Rheinland Energy & Environment GmbH in an independent external review. Furthermore, the database methodology remains compliant with the TfS guideline for PCF and the UEIL/ATIEL methodology. In the course of this update, the methodology has been aligned with the latest versions of these frameworks, specifically TfS version 3.0 (previously version 2.0) and UEIL/ATIEL version 1.2 (previously version 1.0). The compliance with these updated framework versions was also certified as part of the independent external review by TÜV Rheinland Energy & Environment GmbH. In addition, the TÜV review also certifies the compliance of the Carbon Minds

database methodology with the GHG Protocol Product Life Cycle Accounting and Reporting Standard, as well as with guidance from the World Business Council for Sustainable Development (WBCSD).

The independent external review by TÜV Rheinland Energy & Environment GmbH covers the check of methodological approaches, a selected sample of primary and secondary input data, the documentation, the qualification of our employees, the calculation model, and the check of a selected number of output datasets. In Annex C of the Carbon Minds methodology document, a copy of the Review Report by TÜV Rheinland Energy & Environment GmbH on the "Critical Review of the Methodology for the Carbon Minds LCI Database" is attached.

2.2 Addition of renewable chemical datasets

A few months prior to this database update, 1200 new renewable chemical datasets were pre-released to existing database customers. With the V2.03(2026) update, these datasets are now officially included in the full Carbon Minds database and are available by default in all full data products.

The renewable chemical datasets encompass more than 1200 datasets representing the following key renewable production technologies:

- Base oils
    - Re-refining via hydrogenation
    - Re-refining via solvent extraction
    - Re-refining via distillation
- Methane
    - Production from CO_2 via carbon capture and utilization (CCU)
- Methanol
    - Production from CO_2 via carbon capture and utilization (CCU)
- VGO, naphtha, diesel
    - Pyrolysis of mixed plastic waste with lime
    - Pyrolysis of mixed plastic waste with caustic soda

These datasets enable comparisons between fossil and renewable production routes based on region- and technology-specific life cycle data generated using the Carbon Minds database methodology. All renewable chemical models are based on technologies with demonstrated industrial relevance, ensuring that the datasets reflect current industrial practices and realistic technology configurations.

2.3 Integration of ESU-services data

Before the V2.03(2026) database update, data from ESU-services had already been used for crude oil and natural gas modeling in the background of the Carbon Minds database. With the V2.03(2026) database update, additional high-quality and up-to-date datasets from ESU-services are now used to model electricity mixes.

The modeling of electricity mixes is explained in detail in Section 3.1.2.

Through the integration of the ESU-services datasets in the background, the Carbon Minds database ensures methodological consistency as well as temporal and geographical representativeness.

2.4 Carbon Minds database online portal

With the V2.03(2026) database update, Carbon Minds now provides access to its datasets via the Carbon Minds Database Online Portal (https://access.carbonminds.com), which serves as a structured interface to explore dataset documentation, access LCI and LCIA results (depending on the respective license scope), and compare process datasets through an interactive dashboard. The portal provides structured access to metadata, methodological descriptions, and versioned dataset information.

3. Database-wide changes

This chapter describes database-wide changes. These changes can occur in two different ways: a) when updating input data from different database versions to match the reference year or b) when systematic changes in the methodology, e.g., different allocation approaches or changes in the modeling of raw materials at the beginning of the supply chain happen such that it affects the results of most other chemicals and plastics included in the database.

Database-wide changes in the update from V2.02 2024 to V2.03(2026) include the update of the crude oil, natural gas, and electricity datasets in the background of the database, as well as the update of the input data (i.e. market data, trade data, technology data) to the latest reference year. Moreover, systematic methodological changes have been implemented due to the update of the Carbon Minds database methodology to the latest TfS v3.0 compliance. This includes the allocation of TDI and MDI producing datasets according to the IOSPA 2021 PCR, the allocation of CCU-based processes via cut-off instead of using avoided burden and the integration of new data quality ratings according to TfS v3.0. Moreover, the Carbon Minds LCIA method for climate change and the corresponding subcategories were updated.

3.1 Background data

Some background datasets are crucial in chemical value chains with regard to their contribution to environmental impacts of chemicals. These include oil and gas data as well as electricity data. Because these datasets contribute significantly to overall environmental impacts, careful modeling and dataset selection are essential to maintain high data quality for chemical datasets. Therefore, the modeling of crude oil, natural gas, and electricity background datasets has been updated withing the update from V2.02 2024 to V2.03(2026).

Note that most of these datasets are currently not sold and may only be provided on demand in specific cases; they are primarily used to support our chemical value chains and ensure high data quality across the Carbon Minds datasets.

Remaining gaps in background data have been filled using background data from Carbon Minds database version V2.02, which has been individually updated to reflect the new reference year of electricity, crude oil, and natural gas market data.

3.1.1 Crude oil and natural gas LCI modeling

The geographical representativeness of crude oil and natural gas supply is essential, particularly when modeling chemical value chains. Therefore, ESU-services was commissioned by Carbon Minds to model crude oil and natural gas extraction and supply in a regionalized and consistent manner[1,2,3]. With the update from V2.02 2024 to V2.03(2026), the modeling of crude oil and natural gas has been updated from ESU-services data from 2023 to 2025.

For this purpose, country- and region-specific crude oil market mixes are developed based on national production data and international trade statistics. The modeling of crude oil markets covers the most relevant producing countries worldwide, representing approximately 98% of global crude oil and natural gas production, and reflects the supply of crude oil to major destination markets. The modeling includes extraction processes, energy use, flaring, venting, fugitive methane emissions, and transport routes (pipeline and marine transport).

Natural gas supply is modeled with the same level of technical and geographical differentiation: ESU-services develops country- and region-specific natural gas market mixes based on national production data and international trade statistics. The modeling includes associated and non-associated gas production, energy use, flaring, venting, fugitive methane emissions, transport routes (pipeline and LNG transport), as well as regional distribution networks.

3.1.2 Electricity LCI modeling

The geographical and technological representativeness of electricity supply is essential for Life Cycle Assessment (LCA), since electricity is one of the most influential process utilities. Moreover, its environmental profile varies significantly depending on the location of production and consumption, the generation technologies applied, and the voltage level at which electricity is supplied. Therefore, ESU-services was commissioned by Carbon Minds to provide electricity market data in a regionalized and consistent manner.[4]

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[1] Christoph Meili; Niels Jungbluth; Maresa Bussa (2026). Life cycle inventories of crude oil and natural gas extraction. ESU-services Ltd. Commissioned by Carbon Minds, Switzerland. The detailed report is available upon request (info@carbon-minds.com)

[2] Christoph Meili; Niels Jungbluth; Maresa Bussa (2025). Life cycle inventories of long-distance transport of crude oil. ESU-services Ltd. Commissioned by Carbon Minds, Switzerland. The detailed report is available upon request (info@carbon-minds.com)

[3] Maresa Bussa; Niels Jungbluth; Christoph Meili (2025). Life cycle inventories of long-distance transport and distribution of natural gas. ESU-services Ltd. Commissioned by Carbon Minds, Switzerland. The detailed report is available upon request (info@carbon-minds.com)

[4] Maresa Bussa; Angelo Stefanel; Niels Jungbluth (2025). Life cycle inventories of electricity mixes. ESU-services Ltd. Commissioned by Carbon Minds, Switzerland. The detailed report is available upon request (info@carbon-minds.com)

In database versions prior to V2.03(2026), electricity modelling in the Carbon Minds database relied on datasets from the ecoinvent database. With the V2.03(2026) update, the ecoinvent datasets have been replaced with consistent and more recent ESU-services datasets.

To capture geographical and technological variability, ESU-services developed country- and region-specific electricity market mixes, representing the composition of electricity supply differentiated by generation technologies and reflecting cross-border electricity exchanges. The commissioned coverage comprises 120 countries, 36 country sub-grids, and 10 regions, at multiple voltage levels (high, medium, and low voltage). Grid mixes are based on national electricity production statistics and international trade data, thereby reflecting both domestic generation structures and cross-border electricity exchanges. Transmission and distribution (T&D) losses are included to ensure consistent representation of supplied electricity at each voltage level along the supply chain. For the Carbon Minds database, electricity supplied to industrial plants is assumed to be provided exclusively at medium voltage, while underlying background data accounts for the environmental impacts from electricity generation and associated infrastructure requirements.

An exception to the general approach is applied for China to ensure the highest possible quality level for a dominant producer of chemical goods. For the Chinese electricity grid mixes at low, medium, and high voltage, Carbon Minds integrates fully aggregated life cycle inventory (LCI) datasets from HiQLCD[5]. HiQLCD is an established LCA data provider with a focus on high-quality datasets for the Chinese market. The HiQLCD datasets are aligned with the overarching approach in terms of system boundaries, functional unit, and LCI model structure, and are based on official statistics from the Chinese Yearbook.

3.1.3 Other background data

Remaining gaps in background data have been filled using background data from Carbon Minds database version V2.02, which has been individually updated to reflect the new reference year of electricity, crude oil, and natural gas market data.

3.2 Technology data

This data depicts the full mass and energy balances for each production technology. For instance, this data includes information about raw material consumption, utilities (e.g., energy use), resource extractions, emissions, co-products, and waste consumption of the steam cracking of naphtha.

For some individual datasets, updates or corrections have been made in the V2.03(2026) update (see Section 4). Moreover, technology data for more than 200 chemicals have been newly added to the database. Thus, the reference years for this data is 2020 to 2024.

[5] Shanghai HiQ Smart Data Co., Ltd., HiQLCD (https://www.hiq.earth) v1.4.0

3.3 Market data

This data includes, for instance, how much ethylene is produced in Ludwigshafen via the steam cracking of naphtha. Furthermore, this data includes meta-information, like the company operating the plant (e.g., the BASF in Ludwigshafen) or the first year of operation.

The market data has been updated to the reference year 2024.

3.4 Trade data

This data depicts, for instance, the imports of ethylene from the Netherlands to Germany. Including this data allows an understanding of which chemical is traded between countries.

The trade data has been updated to the reference year 2024.

3.5 Systematic methodological changes

Systematic methodological changes have been implemented due to the update of the Carbon Minds database methodology to the latest TfS v3.0 compliance. This includes the allocation of TDI and MDI producing datasets according to the IOSPA 2021 PCR, the allocation of CCU-based processes via cut-off and the integration of new data quality ratings according to TfS v3.0.

3.5.1 Allocation of TDI and MDI

Previously, the ISOPA 2012 PCR version was applied. In the V2.03(2026) database update, this has been replaced by ISOPA 2021, as TfS specifies that ISOPA 2021 shall be used according to their "List of accepted PCRs by TfS". As a result, the allocation approach has changed from mass allocation (ISOPA 2012) to an allocation approach based on mass and physical relationships defined in ISOPA 2021. For the following processes, allocation according to the official Product Category Rule (PCR), *Toluene Diisocyanate (TDI) & Methylenediphenyl Diisocyanate (MDI), Eco-profiles and Environmental Product Declaration of the European Plastic Manufacturers by ISOPA*[6], is applied:

- production of MDI by phosgenation
- TDI production from toluene
- hydrogenation of methylenedianiline

3.5.2 Allocation of Carbon Capture and Utilization

Processes that produce a chemical product and at the same time capture CO_2 that can be used in subsequent downstream processes, known as Carbon Capture and Utilization (CCU), are multifunctional processes. This multifunctionality was previously

[6] ISOPA, 2021. Eco-profile of toluene diisocyanate (TDI) and methylene diphenyl diisocyanate (MDI).

addressed using an avoided burden approach, where Direct Air Capture was considered the avoided process. This approach has now been replaced by the cut-off approach described below.

In the Carbon Minds database, CO_2 co-production occurs in ammonia production plants: For ammonia production based on steam reforming of natural gas with air and based on gasification of coal with air, CO_2 capture is considered an integral part of the ammonia production process. The additional energy demand for capture is negligible compared to total plant energy demand and is therefore neglected, as the CO_2 stream is already highly concentrated and can be separated with comparatively low additional effort. Thus, the captured CO_2 leaving the ammonia plant is treated as a co-product without upstream burden from the capture step.

When the captured CO_2 is consumed in downstream processes, such as urea production, it is supplied after capture without allocation of additional capture burdens. Accordingly, the CO_2 input to downstream plants consuming the CO_2 is modeled as burden-free.

3.5.3 Integration of additional data quality ratings according to TfS v3.0

Before the V2.03(2026) database update, two data quality schemes were offered to quantify the quality of the Carbon Minds datasets: the Carbon Minds scheme and a joint data quality scheme for TfS and UEIL/ATIEL. With the V2.03(2026) database update, a separate data quality scheme for TfS v3.0 has been introduced. As a result, the Carbon Minds database now includes three data quality schemes:

- Data quality requirements according to Carbon Minds
- Data quality requirements according to the TfS v3.0 guidelines
- Data quality requirements according to the UEIL/ATIEL methodology

It is up to the dataset user, depending on the requirements specified in their PCF or LCA methodology, to decide which data quality scheme shall be used.

As the data quality requirements according to TfS v3.0 are newly introduced in the V2.03(2026) database update, they are described in detail below:

According to TfS, the data quality indicators represent three data quality criteria: Technological representativeness (TeR), Geographical representativeness (GeR), and Time-related representativeness (TiR). For each criterion, five data quality levels (instead of three levels, as in previous TfS versions) exist, where level 1 represents the highest data quality and 5 the lowest. Additionally, the Data Quality Rating (DQR) is calculated to provide a quantitative information of the overall quality of the data and the resulting Product Carbon Footprint (PCF).

Table 1 shows the definition of each data quality criterion according to TfS.

Table 2 gives an overview of the data quality assessment scheme for each data quality criterion and data quality level according to TfS.

Table 1. Definitions of data quality criteria according to TfS.

Technological representativeness	The degree to which the data reflects the actual technology(ies) used.
Geographical representativeness	The degree to which the data reflects the actual geographic location of the activity (e.g. country or site).
Time-related representativeness	The degree to which the data reflects the actual time (e.g. year) or age of the activity.
Data quality rating (DQR)	The DQR is calculated to provide a quantitative information of the overall quality of the data and the resulting Product Carbon Footprint. In simple terms, the DQR is an average of the three data quality criteria described above.

Table 2. Assessment scheme for the determination of data quality criteria and quality level according to TfS.

Quality level	**1 – Very good**	**2 – Good**	**3 – Fair**	**4 – Poor**	**5 – Very poor**
Technological representativeness	Same technology, plant specific (primary data)	Same technology, company/ site specific (primary data)	Same technology, not company-specific (secondary data)	Similar technology (secondary data)	Different or unknown technology
Geographical representativeness	Same country or country subdivision	Same country	Same region or subregion	Global average	Geography unknown or not representative
Time-related representativeness	Data ≤ 1 year old	Data > 1 and ≤ 2 year old	Data > 2 and ≤ 3 year old	Data > 3 and ≤ 4 year old	Data > 4 years old
Data quality rating (DQR)	Overall very good quality by considering all three data quality criteria described above.	Overall good quality by considering all three data quality criteria described above.	Overall fair quality by considering all three data quality criteria described above.	Overall poor quality by considering all three data quality criteria described above.	Overall very poor quality by considering all three data quality criteria described above.

3.6 Carbon Minds LCIA method update

The Carbon Minds database provides elementary flow inventories and can therefore be used with any LCIA method implemented in the Carbon Minds characterization matrix (e.g., EF 3.1, ReCiPe, or other LCIA frameworks). In addition, Carbon Minds developed its own LCIA methods to support consistent product carbon footprint calculations according to relevant standards and guidelines.

In previous versions of the Carbon Minds database, only one LCIA method developed internally by Carbon Minds for the climate change impact category was provided: "Carbon Minds ISO 14067 (based on IPCC 2021)". In the V2.03(2026) database update, this LCIA method has been renamed to "Carbon Minds ISO 14067 (based on IPCC 2021 incl. biogenic)" to more clearly reflect the treatment of biogenic carbon flows.

Moreover, with the V2.03(2026) database update, two additional Carbon Minds LCIA methods for climate change have been introduced in order to support different reporting requirements and methodological frameworks used by database users:

- "Carbon Minds ISO 14067 with biogenic CO_2 correction (based on IPCC 2021 incl. biogenic)", which implements the biogenic CO_2 correction as defined by the TfS guideline.
- "Carbon Minds (based on IPCC 2021 excl. biogenic)", which excludes biogenic CO_2 flows from the characterization of climate change impacts and can be used for applications such as PEF-aligned assessments.

As a result, the Carbon Minds database now provides three Carbon Minds LCIA methods for the climate change impact category, allowing users to select the method that best fits the requirements of their specific LCA or PCF study.

Users should refer to the Carbon Minds database methodology document (Section 3.2.4 – Supported LCIA methods) for a detailed description of the implemented LCIA methods, their methodological principles, and their intended use cases.

Moreover, Annex B of the Carbon Minds database methodology document describes how LCA practitioners can report the impact categories according to the TfS data model.

4. Updates and changes in individual datasets

This section describes the updates and changes for specific datasets.

4.1 Core layer

The following chemicals and processes were changed in the core layer:

- methylene diphenyl diisocyanate: The processes "production of MDI by phosgenation (CO from coal)" and "production of MDI by phosgenation (CO from NG)" were updated to align with the latest allocation rules for MDI and TDI processes (ISOPA 2021).
- toluene diisocyanate: The processes "TDI production from toluene (CO from coal)" and "TDI production from toluene (CO from natural gas)" were updated to align with the latest allocation rules for MDI and TDI processes (ISOPA 2021).
- petroleum coke: The process "delayed coking" was added to the core layer to increase data quality and granularity. Petroleum coke, also known as green coke, is traded globally as high-purity reduction agent for base chemical production, e.g. for mineral acids.

4.2 Extension layer

The following chemicals and processes were changed in the extension layer:

- methylene diphenyl diisocyanate (hydrogenated): The process "hydrogenation of methylenedianiline" was updated to align with the latest allocation rules for MDI and TDI processes (ISOPA 2021).
- hydrogen chloride: The process "hydrogenation of methylenedianiline" was updated to align with the latest allocation rules for MDI and TDI processes (ISOPA 2021).
- o-toluenediamine: The process "TDI production from toluene (CO from natural gas)" was updated to align with the latest allocation rules for MDI and TDI processes (ISOPA 2021).
- ethylene/vinyl acetate (EVA) copolymer: In the process "autoclave reactor" directs emissions from waste incineration were corrected.
- petroleum coke/green coke: All processes for green coke or petroleum coke were removed as they are now implemented in "delayed coking" in the core layer.
- sodium carbonate (ammonia-based): The waste model for "carbonation of sodium chloride solution", commonly known as *Solvay process*, was adjusted to include public information about waste- and by-product fate. Per 1 kg soda reference product, 0.037 kg of calcium chloride are assumed as by-product and the mass balance is then closed through a custom waste model. Sodium, calcium, chloride and limestone impurity (Fe, Al, Mg, SiO2) ion elementary flows and land use are now adjusted to represent effluent disposal into water bodies after detention time in settling ponds, landfilling of insoluble components on HDPE liner and leakage into groundwater.
- sodium carbonate (trona-based): The process "trona carbonation via monohydrate process" was added to model trona-based production processes.
- sodium carbonate (trimethylamine-based): the process "acquisition by trimethylamine" was removed due to missing industrial relevance.
- bisphenol A diglycidyl ether (DGEBPA): The process "o-alkylation of bisphenol A with epichlorohydrin" was corrected to account for sodium-chloride waste.
- base oil (type I, from re-refining via hydrogenation)/ base oil (type II, from re-refining via hydrogenation)/ base oil (type III, from re-refining via hydrogenation): The process "re-refining of base oils via hydrogenation" was corrected since energy co-products are typically used for energy co-production instead of mass allocation.
- base oil (type I, from re-refining via distillation): The process "re-refining of base oils via distillation" was corrected since energy co-products are typically used for energy co-production instead of mass allocation.
- base oil (type I, from re-refining via extraction): The process "re-refining of base oils via extraction" was corrected since energy co-products are typically used for energy co-production instead of mass allocation.

4.3 Simplified extension layer

The following chemicals and processes were changed in the simplified extension layer:

- sodium dithionite: The process "formate process of sodium formate, sulfur dioxide and caustic soda" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- vanillin: The process "reaction of guaiacol, glyoxylic acid and oxygen" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- propiophenone: The process "ketonization of benzoic acid and propionic acid" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- n,n-dimethylbenzylamine: The process "eschweiler-clarke methylation of benzylamine" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- 2-hydroxy-4'-(2-hydroxyethoxy)-2-methylpropiophenone: The process "reaction of 3-(4-(2-hydroxyethoxy)phenyl)-2-methylbut-3-en-2-ol and oxygen" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- 2-(4-bromophenoxy)ethanol: The process "reaction of p-bromophenol and ethylene carbonate" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- calcium sulfate: The process "reaction of calcium carbonate and sulfuric acid" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- calcium 2,2-thiobis(4-dodecylphenolate): The process "production of calcium 2,2-thiobis(4-dodecylphenolate)" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- neutral calcium sulphonate detergent: The process "production of neutral calcium sulphonate detergent" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- overbased calcium sulphonate detergent: The process "production of overbased calcium sulphonate detergent" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- trisodium citrate dihydrate: The process "reaction of citric acid and soda ash (sodium carbonate)" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- calcium acetate: The process "reaction of calcium acetate with acetic acid" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- calcium sulfite: The process "reaction of calcium carbonate and sulfur dioxide" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.

- calcium metasilicate: The process "reaction of calcium carbonate and silica sand" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- strontium sulfide: The process "reaction of strontium sulfate and carbon black" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- sodium tripolyphosphate: The process "reaction of phosphoric acid and sodium carbonate (ammonia-based)" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- disodium hydrogen phosphate (from phosphonic acid): The process "reaction of phosphonic acid and sodium carbonate" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- MDI oligomer (n=2): The process "autopolymerization of methylene diphenyl diisocyanate (4,4'-MDI) with n=2" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- MDI oligomer (n=3): The process "autopolymerization of methylene diphenyl diisocyanate (4,4'-MDI) with n=3" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- MDI oligomer (n=4): The process "autopolymerization of methylene diphenyl diisocyanate (4,4'-MDI) with n=4" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- MDI oligomer (n=5): The process "autopolymerization of methylene diphenyl diisocyanate (4,4'-MDI) with n=5" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- MDI oligomer (n=6): The process "autopolymerization of methylene diphenyl diisocyanate (4,4'-MDI) with n=6" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- N,N'-dicyclohexylcarbodiimide (DCC): The process "reaction of cyclohexylisocyanat" was remodeled by treating the co-produced CO_2 as an emission instead of a process co-product.
- hexamethylene diisocyanate homopolymer (30 hexamethylene diisocyanate units): For the process "reaction of hexamethylene diisocyanate" the waste model emissions were corrected.
- 4,4'-diaminodiphenylmethane: The simplified extension layer process "reaction of aniline and formaldehyde with reaction conditions for 4,4'-diaminodiphenylmethane" was removed as it was a duplicate of the higher data quality process "reaction of aniline and formaldehyde" which is producing 4,4'-methylenedianiline (same chemical).
- tert-butyl hydroperoxide: The precursor was changed from isobutylene to isobutane to consider industrial practices. The producing process changed from "reaction of isobutylene and oxygen" to "reaction of isobutane and oxygen".
- pelargonic acid (biogenic): The process "ozonolysis of oleic acid" is now producing azelaic acid and pelargonic acid (biogenic).
- nonanoic acid: The product and the producing process "reaction of oleic acid and water" were removed as pelargonic acid (biogenic) from *ozonolysis of oleic acid* is replacing them.

- ethylene butylen copolymer (n,m = 11882, 1:1): incompatible symbol was corrected in the chemical name.
- ethylene hexene copolymer (n,m = 8912, 1:1): incompatible symbol was corrected in the chemical name.
- ethylene-octene copolymer (solution-based, w_ethylene=0.67, w_octene=0.33): incompatible symbol was corrected in the chemical name.
- 2-benzoylbenzoic acid: The precursor was changed from phenylmagnesium bromide to benzene to consider industrial practices. The producing process changed from "reaction of phthalic anhydride and phenylmagnesium bromide" to "reaction of benzene and phthalic anhydride".
- 4-methylbenzophenone (4-MBZ): The precursor was changed from benzoic acid to benzoyl chloride to consider industrial practices. The producing process changed from "reaction of toluene and benzoic acid" to "reaction of toluene and benzoyl chloride".
- tallow nitriles: incompatible symbol was corrected in the producing process name.
- coco fatty nitriles: incompatible symbol was corrected in the producing process name.
- bis(N,N dibutylcarbamodithioato)di-m-oxodioxodi-molybdenum, sulfurized: incompatible symbol was corrected in the producing process name.
- 3,3'-iminobis(N,N-dimethylpropylamine): incompatible symbol was corrected in the chemical name.
- 3,3'-dichlorbenzidin: incompatible symbol was corrected in the chemical name.
- linoleic acid: Prices for all products from "hydrolysis of palm oil" were researched in a comparable way to ensure correct economic allocation.
- myristic acid: Prices for all products from "hydrolysis of palm oil" were researched in a comparable way to ensure correct economic allocation.
- oleic acid: Prices for all products from "hydrolysis of palm oil" were researched in a comparable way to ensure correct economic allocation.
- palmitic acid: Prices for all products from "hydrolysis of palm oil" were researched in a comparable way to ensure correct economic allocation.
- stearic acid from palm oil: Prices for all products from "hydrolysis of palm oil" were researched in a comparable way to ensure correct economic allocation.
- benzyl chloride: The process "chlorination of toluene side train" was renamed to "chlorination of toluene side-chain" and now considers hydrochloric acid (recovered) as by-product. Possible HCl/Cl recovery loops in integrated plants are outside the system boundaries as the process might occur with or without them. Hydrochloric acid (recovered) as by-product adds energy demand to the process but reduces the amount of waste incineration used by the waste model to close the mass balance.
- 2,4-dichlorophenol: The process "chlorination of phenol" is now producing 2,4-dichlorophenol now considers hydrochloric acid (recovered) as by-product. Possible HCl/Cl recovery loops in integrated plants are outside the system boundaries as the process might occur with or without them. Hydrochloric acid (recovered) as by-product adds energy demand to the process but reduces

the amount of waste incineration used by the waste model to close the mass balance.

- 2,6-dichlorophenol: The precursor was changed from phenol to 2-chlorophenol to consider industrial practices. The producing process changed from "reaction of phenol and chlorine" to "reaction of 2-chlorophenol and chlorine".
- 4-chlorophenol: The product p-chlorophenol was renamed to 4-chlorophenol to be in line with the naming of the 2-chlorophenol by-product of the "direct chlorination of phenol" process. Prices of both byproducts are adjusted and the default 35/65 ratio in favor of the 4-chlorophenol main product under default conditions without selectivity tuning is assumed. The process now considers hydrochloric acid (recovered) as by-product. Possible HCl/Cl recovery loops in integrated plants are outside the system boundaries as the process might occur with or without them. Hydrochloric acid (recovered) as by-product adds energy demand to the process but reduces the amount of waste incineration used by the waste model to close the mass balance.
- 2-chlorophenol: The product is now produced as a by-product from the same "direct chlorination of phenol" process as 4-chlorophenol instead of the separate "reaction of phenol and chlorine" process.
- polyisobutylbenzene (28C PIB): The product was removed as it was a duplicate of dipolyisobutylbenzene (28C).

Annexes

Annex A. List of added chemicals to the Carbon Minds database

This annex lists all chemical and process names that were additionally added in Version 2.03(2026).

Chemical Name	Process Name
1,2-ethanediamine, polymer with 2-methyloxirane	reaction of ethylenediamine and propylene oxide
1,2-propanediol diacetate	reaction of propylene oxide and acetic acid
1,3-butanediol	reaction of 3-hydroxybutanal and hydrogen
1,3-dimethyl-2-nitrobenzene	nitration of m-xylene
1,4-benzenedicarbonyl dichloride, polymer with 1,4-benzenediamine	reaction of p-phenylenediamine and 4-carbonochloridoylbenzoic acid
1,4-dihydroxy-9,10-anthrachinon	acid-catalyzed aromatic substitution
1-allyl-3-methylimidazolium chloride	reaction of 1-methylimidazol and allyl chloride
1-butoxy-2-propanol	reaction of n-butanol and propylene oxide
1-decene, polymer with 4-methyl-1-pentene	reaction of ethylene and 4-methylpentene-1
1-ethoxy-2-propanol	ring-openening addition of propylene oxide and ethanol to 1-ethoxy-2-propanol
1-hydroxy-4[(methyl phenyl)amino] anthracene-9-10-dione	alkylation of p-toluidine with chinizarin
1-methylimidazol	reaction of imidazole and methanol
1-methylnaphthalene	reaction of naphthalene and methyl chloride
1-octadecene, polymer with 1-hexadecene and 4-methyl-1-pentene	reaction of ethylene and 4-methylpentene-1
2-(2-butoxyethoxy)ethyl acetate	fischer esterification of butoxydiethylenglycol and acetic acid to butoxy-ethoxy-ethyl acetate
2,3-dichloropyridine	Selective 3-chlorination of 2-chloropyridine with chlorine
2,3-Epoxypropyl methacrylate	reaction of methacrylic acid and epichlorohydrin
2,3-epoxypropyl neodecanoate	base-promoted dehydrohalogenation
2,4,4-trimethyl pentene, sulfurized	sulfurization of diisobutylene
2,4-di-tert-butylphenol	reaction of p-t-butylphenol and t-butanol
2,5-furandione, polymer with ethene and 1-octene	reaction of maleic anhydride and ethylene
2,6-anthraquinone disulfonic acid	beta-disulfonation of anthraquinone
2,6-dihydroxyanthraquinone	alkaline desulfonative hydroxylation of 2,6-anthraquinone disulfonic acid
2,7-anthraquinone disulfonic acid	beta-disulfonation of anthraquinone
2-aminoethyl hydrogen sulfate	reaction of monoethanolamine and sulfuric acid

2-chloropyridine N-oxide	peracid oxidation of 2-chloropyridine
2-ethyl-2-oxazoline	reaction of monoethanolamine and propionic acid
2-ethylhexanoic acid	reaction of 2-ethylhexanol and oxygen
2-ethylhexyl 3-cyclohexene-1-carboxylate	transesterfication of methyl tetrahydrobenzoate and ethylhexanol
2-ethylhexyl methacrylate	transesterification of methyl methacrylate and 2-ethylhexanol to 2-ethylhexyl methacrylate
2-ethylhexyl nitrate	reaction of nitric acid and 2-ethylhexanol
2-hydroxyethyl acrylate (HEA)	ring-openening addition of acrylic acid and ethylene oxide to 2-hydroxyethyl acrylate
2-methyl-1,3-propanediol	reaction of formaldehyde and hydrogen and propionaldehyde
2-phenoxyethyl acrylate	reaction of acrylic acid and 2-phenoxyethanol
2-Propenoic acid, 2-methyl-, methyl ester, polymer with 1,3-butadiene, butyl 2-propenoate and ethenylbenzene	reaction of butadiene and styrene
3-(3-methoxy-3-oxopropyl)sulfanylpropanoic acid	reaction of methyl acrylate and 3-mercaptopropionic acid
3-(3-octadecoxy-3-oxopropyl)sulfanylpropanoic acid	reaction of 1-octadecanol and 3-(3-methoxy-3-oxopropyl)sulfanylpropanoic acid
3,3'-iminobis(N,N-dimethylpropylamine)	dimerization of n,n-dimethyl-1,3-propanediamine with condensation of ammonia
3,5-dimethyl-1,3,5-thiadiazinane-2-thione (dazomet)	reaction of monomethylamine and carbon disulfide and formaldehyde
3,5-dimethylpyrazole	condensation of acetylacetone with hydrazine
3,5-di-tert-butyl-4-hydroxybenzoic acid	carbonylation of 2,6-di-tert-butylphenol
3,7-dimethyl-1,6-octadien-3-ol (linalool)	allylic isomerization of geraniol/nerol isomer mix
3-hydroxybutanal	dimerization acetaldehyde
3-mercapto-2-methylpropionic acid	reaction of methacrylic acid and hydrogen sulfide
3-methyl-2-nitrobenzoic acid	oxidation of 1,3-dimethyl-2-nitrobenzene
3-methylbutyl 3-methylbutanoate	reaction of 3-methyl-1-butanol and isovaleric acid
3-methylbutyl butyrate	reaction of 3-methyl-1-butanol and butyric acid
4-(2,4,4-trimethylpentan-2-yl)phenol	reaction of isobutylene dimer and phenol
4-(4-hydroxyphenyl)-2-butanone	reaction of 4-hydroxybenzaldehyde and acetone and hydrogen
4-[(4-isocyanatophenyl)methyl]aniline	reaction of 4,4'-methylenedianiline and phosgene
4-carbonochloridoylbenzoic acid	reaction of terephthalic acid and hydrogen chloride
4-hydroxybenzaldehyde	reaction of p-cresol and oxygen

4-hydroxybutyl acrylate	transesterification of 1,4-butanediol and methyl acrylate to 4-hydroxybutyl acrylate
7-oxabicyclo[4.1.0]heptane 3-carboxylic acid, 2-ethylhexyl ester	peracid epoxidation of 2-ethylhexyl 3-cyclohexene-1-carboxylate
acrylic acid-ethylene copolymer	reaction of acrylic acid (ester-grade) and ethylene
acrylic acid-ethylene copolymer zinc salt	reaction of ethylene and acrylic acid (ester-grade)
acrylonitrile-butyl acrylate-styrene copolymer	reaction of styrene and acrylonitrile
adipic acid 1,4-butanediol copolymer (PBA)	reaction of adipic acid and 1,4-butanediol
allyl methacrylate	transesterification of allyl alcohol and methyl methacrylate to allyl methacrylate
aminoguanidine bicarbonate	reaction of hydrazine and water and carbon dioxide
antimony tris[O,O-dipropyl] tris(dithiophosphate) (Sb-DDP)	reaction of O,O-diisopropyl hydrogen dithiophosphate and antimony(III) oxide
antimony(III) oxide	reaction of antimony and oxygen
aziridine (ethyleneimine)	reaction of 2-aminoethyl hydrogen sulfate and caustic soda (50%)
barium sulfate	precipitation of barium sulfate
base oil (type I, from re-refining via distillation)	re-refining of base oils via distillation process
base oil (type I, from re-refining via extraction)	re-refining of base oils via solvent extraction process
base oil (type I, from re-refining via hydrogenation)	re-refining of base oils via hydrogenation process
base oil (type II, from re-refining via hydrogenation)	re-refining of base oils via hydrogenation process
base oil (type III, from re-refining via hydrogenation)	re-refining of base oils via hydrogenation process
benzenamine, N-phenyl-, reaction products with 2,4,4-trimethylpentene	reaction of diphenylamine and diisobutylene
bis(N,N dibutylcarbamodithioato)di-m-oxodioxodi-molybdenum, sulfurized	MoDTC oxysulfide formation and sulfurization
blocked polyisocyanate	polymerization of trimers of HDI and dimethylpyrazole
borated PIBSA - polyamine dispersant (PIBSA-PAM-B)	reaction of polyisobutylene succinimide (Bis-PIBSI, 2:1) and boric acid
BPA/epichlorohydrin epoxy resin, chloromethyl/propyl oxide modified	reaction of bisphenol A diglycidyl ether (DGE-BPA) and propylene oxide
branched polyethylenimine (bPEI, x=40)	reaction of aziridine (ethyleneimine)
butadiene-methyl methacrylate-styrene copolymer	reaction of butadiene and styrene
butyl 2-hydroxyacetate	fischer esterification of n-butanol and glycolic acid to butyl hydroxyacetate
butyl acetate	fischer esterification of acetic acid and n-butanol to n-butyl acetate

butyl acrylate-ethylene copolymer	reaction of ethylene and n-butanol
butyl acrylate-methyl methacrylate copolymer	reaction of n-butyl acrylate and methacrylic acid
calcium carbonate (precipitated)	precipitation of calcium cabonate from carbon dioxide in calcium hydroxide solution
caprolactone (oxepan-2-one)	reaction of cyclohexanone and peracetic acid
carbamodithioic acid, dicoco-alkyl derivs., potassium salts	dicoco DTC-K ligand salt formation via secondary dicoco amine, carbon disulfide and potassium hydroxide
citral	acetal/condensation-rearrangement of prenol and prenal
coco fatty nitriles	ammoniation-dehydration of fatty acids from coconut oil with ammonia
coco monoglyceride	reaction of C8-C10 fatty acids (coconut oil) and glycerin
copper(I) iodide	production of high purity CuI by reaction of elemental copper and iodine
cyclohexyl methacrylate (CHMA)	transesterification of cyclohexanol and methyl methacrylate to cyclohexyl methacrylate
di-2-ethylhexyl azelate	esterification of ethylhexanol and azelaic acid
dicoco alkyl amine	coco fatty nitrile hydrogenation to secondary amine
diesel (C8-C18), from pyrolysis of mixed waste with caustic soda	pyrolysis of mixed waste with caustic soda
diesel (C8-C18), from pyrolysis of mixed waste with lime	pyrolysis of mixed waste with lime
diethyl maleate	reaction of maleic acid and ethanol
dimethylformamide (DMF)	reaction of dimethylamine and carbon monoxide (synthesis gas (1:1))
dipentaerythritol	pentaerythritol production with multi-stage recrystallization and purification
diphenyl sulfone	reaction of benzene and benzenesulfonyl chloride
distearyl thiodipropionate	reaction of 1-chlorooctodecane and 3-(3-octadecoxy-3-oxopropyl)sulfanylpropanoic acid
di-tert-butyl peroxide (DTBP)	dimerization of tert-butyl hydroperoxide
dodecanoic acid	reaction of n-dodecanol and oxygen
dodecene-1	fractionation of alpha olefins (SHOP)
ethanedioic acid, 1,2-diethyl ester, polymer with 1,2-ethanediamine	reaction of ethylenediamine and monoethyl oxalate
ethyl 3-ethoxypropionate	addition of ethyl acrylate and ethanol to ethyl-3 ethoxypropionate
ethyl acrylate-ethylene-maleic anhydride copolymer	reaction of maleic anhydride and ethylene
ethyl acrylate-methyl methacrylate copolymer	reaction of ethyl acrylate and methacrylic acid
ethyl hexanoate	reaction of ethanol and hexanoic acid

ethyl methacrylate	reaction of methacrylic acid and ethanol
ethylene bis(oleamide)	reaction of oleic acid and ethylenediamine
ethylene butylen copolymer (w_ethylene=0.9, w_butylene=0.1)	ethylene butylen copolymer by a high pressure autoclave process
ethylene hexene copolymer (w_ethylene=0.9, w_hexene=0.1)	ethylene hexene copolymer by a high pressure autoclave process
ethylene-glycidyl methacrylate-methyl acrylate copolymer	reaction of ethylene and 2,3-Epoxypropyl methacrylate
ethylene-methyl acrylate copolymer	reaction of ethylene and methanol
ethylene-octene copolymer (solution-based, w_ethylene=0.67, w_octene=0.33)	solution-based ethylene-octene co-polymerization
ethylene-vinyl alcohol copolymer (EVOH)	methanolysis of ethylene/vinyl acetate (EVA) copolymer
fatty acids, C18-unsatd., dimers	dimerization of tall oil fatty acids
formaldehyde, polymer with 4-nonylphenol and 4-(1,1,3,3-tetramethylbutyl)phenol	reaction of 4-(2,4,4-trimethylpentan-2-yl)phenol and phenol
geraniol/nerol isomer mix	hydrogenation of citral
glycerol propoxylate-b-ethoxylate (glycerol EO/PO block copolymer)	polymerization of glycerin and propylene oxide and ethylene oxide
glycerol-initiated EO/PO polyether triol (13:22:65)	reaction of glycerin and ethylene oxide and propylene oxide
graphite	graphite prodcution via Acheson process (factual source: ACS Sustainable Chemistry & Engineering 2022 10 (41), 13607-13618, no reproduction)
hexadecene-1	fractionation of alpha olefins (SHOP)
hexadecyl 3,5-di-tert-butyl-4-hydroxybenzoate	reaction of 3,5-di-tert-butyl-4-hydroxybenzoic acid and 1-hexadecanol
hexanedioic acid, polymer with 1,4-butanediol and 1,1-methylenebis4-isocyanatobenzene	reaction of adipic acid and 4-[(4-isocyanatophenyl)methyl]aniline
hexanoic acid	reaction of 1-hexanol and oxygen
hydrogenated dilinoleyl alcohol	dimerization and hydrogenation of linoleic acid
hydrogenated rosin	hydrogenation of tall oil rosin
hydroquinone bis(2-hydroxyethyl) ether	reaction of hydroquinone and ethylene oxide
hydroxyethyl methacrylate (HEMA)	ring-openening addition of ethylene oxide and methacrylic acid to 2-hydroxyethyl methacrylate
hydroxypropyl acrylate (HPA)	reaction of acrylic acid and propylene oxide
hydroxypropyl methacrylate (HPMA)	ring-openening addition of propylene oxide and methacrylic acid to HPMA
isobutyl acetate	fischer esterification of isobutanol and acetic acid to isobutyl acetate
isobutyl methacrylate	reaction of methacrylic acid and isobutanol

isononyl benzoate	esterification of isononyl alcohol and benzoic acid (generalized energy)
isophorone-diisocyanate polymer (IDPI)	polymerization of isophorone diisocyanate to homopolymer
isoprenol	Prins condensation of isobutylene and formaldehyde
isopropyl myristate (IPM)	reaction of isopropanol and myristic acid
isovaleraldehyde	reaction of isobutylene and carbon monoxide and hydrogen
isovaleric acid	reaction of isovaleraldehyde and oxygen
lauric acid diethanolamide	reaction of diethanolamine and dodecanoic acid
lithium stearate	saponification of stearic acid with lithium hydroxide
melamine	reaction of urea (agricultural grade)
methane, from CO2-based production	methane from CO2 from CCU with CO2 recycle
methanol, from CO2-based production	methanol from CO2 from CCU with CO2 recycle
methyl 3-cyclohexene-1-carboxylate	2+4 cycloaddition of butadiene and methyl acrylate
methyl ethyl ketoxime (2-butanone oxime)	reaction of methyl ethyl ketone (butanol-based) and hydroxylamine
methyl hydrogenated rosinate	methoxylation of hydrogenated rosin
methylhydrazine	reaction of monomethylamine and ammonia
Mo(VI) coco diolates (from cocamide-DEA & monoacylglyceride)	reaction of coco monoglyceride and N,N-bis(2-hydroxyethyl) nonanamide and molybdenum trioxide
molybdenum disulfide	sulfurization of molybdenum oxide
mono- and bis- (branched & linear pentyl) phosphate esters (amyl acid phosphates)	reaction of phosphoric acid (as P2O5) and 3-methyl-1-butanol and pentanol
monoethyl oxalate	reaction of oxalic acid and ethanol
monopentaerythritol	pentaerythritol production with multi-stage recrystallization and purification
N,N-bis(2-hydroxyethyl) nonanamide	reaction of C8-C10 fatty acids (coconut oil) and diethanolamine
N,N'-bis(salicylidene)-1,2-propanediamine	reaction of salicylaldehyde and 1,3-propanediamine
N,N-dimethylcyclohexylamine	reaction of cyclohexylamine and methanol
naphtha light (C2-C8), from pyrolysis of mixed waste with caustic soda	pyrolysis of mixed waste with caustic soda
naphtha light (C2-C8), from pyrolysis of mixed waste with lime	pyrolysis of mixed waste with lime
n-butyl methacrylate	transesterification of methyl methacrylate and n-butanol to n-butyl methacrylate
N-butyl-2-pyrrolidone	reaction of butyrolactone and n-butylamine
n-butylbenzenesulfonamide	reaction of benzenesulfonyl chloride and n-butylamine

neodecanoic acid	koch carbonylation of nonene
N-ethylpiperidine	reaction of ethyl chloride and piperidine
n-methyl-2-pyrrolidone (NMP)	reaction of butyrolactone and monomethyl-amine
N-methylimidazole	methylation of imidazole
N-oleyl-1,3-propanediamine	reaction of oleyl aldehyde and 1,3-propane-diamine and hydrogen
O,O-diisobutyl phosphorochlo-ridothioate	reaction of thiophosphoryl chloride and iso-butanol
octadec-1-ene	fractionation of alpha olefins (SHOP)
octadecyl 3-(3,5-di-tert-butyl-4-hy-droxyphenyl)propionate	reaction of methyl 3,5-di-tert-butyl-4-hydroxy-phenyl-1-propionate and 1-octadecanol
oleyl aldehyde	reaction of oleyl alcohol and oxygen
oleyl phosphate (mono- and di-es-ter)	reaction of oleyl alcohol and phosphoric acid
oxaldehyde	oxidation of ethylene glycol
pelargonic acid (biogenic)	ozonolysis of oleic acid
pentaerythrityl tetrastearate	reaction of monopentaerythritol and stearic acid from palm oil
pentyl acetate	fischer esterification of acetic acid and pen-tanol to pentyl acetate
poly(1-decene sulfone)	reaction of decene-1 and sulfur dioxide
poly(2-ethyl-2-oxazoline), PEtOx	polymerization of 2-ethyl-2-oxazoline
poly(butylene adipate-co-ethylene adipate) (PBAE)	reaction of adipic acid and 1,4-butanediol and ethylene glycol
poly(N,N-dimethyl-2-hydroxyprop-ylammonium chloride)	polymerization of epichlorohydrin and dime-thylamine
poly(oxy-1,2-ethanediyl) α-phenyl-ω-hydroxy phosphate	polymerization of phenol, ethanol and phos-phoric acid
poly(propylene-co-1-butene-co-eth-ylene) (PP terpolymer, 5 mol% bu-tene, 4 mol% ethylene)	polymerization of propylene, butene-1,eth-ylene in 910:50:40 ratio
polyethylene glycol monomethyl ether (mPEG-500)	reaction of methanol and ethylene oxide
polyethylenimine, 80 % ethoxylated	reaction of branched polyethylenimine (bPEI, x=40) and ethylene oxide
polyisobutylene succinimide (Bis-PIBSI, 2:1)	reaction of polyisobutenyl succinic anhydride (PIBSA, 1:1, N,M=10) and triethylenetetramine
potassium bisulfate	initial stage of the mannheim process for po-tassium sulfate production
potassium diphenyl sulfone-3-sul-fonate	reaction of diphenyl sulfone and sulfur triox-ide
potassium persulfate	electrolysis of potassium bisulfate in sulfuric acid
PPG-10 cetyl ether (ceteth-10, propoxylated cetyl alcohol)	propoxylation of 1-hexadecanol
PPG-15 stearyl ether	reaction of 1-octadecanol and propylene oxide
prenal	reaction of isoprenol and oxygen

prenol	isomerization of isoprenol
propan-2-amine	reaction of acetone and ammonia and hydrogen
propanoic acid, 3-[[bis(2-methylpropoxy)phosphinothioyl]thio]-2-methyl-	reaction of O,O-diisobutyl phosphorochloridothioate and 3-mercapto-2-methylpropionic acid
rapeseed oil methyl ester	reaction of fatty acids (from rape oil) and methanol
salicylaldehyde	reaction of salicylic acid and thionyl chloride and hydrogen
silica, amorphous	precipitated silica via sodium silicate and sulfuric acid
sodium carbonate (trona-based)	trona carbonation via monohydrate process
sodium dibutyldithiocarbamate	DDBTC-Na ligand salt formation via dibutyl amine, carbon disulfide and sodium hydroxide
sodium dichloroisocyanurate dihydrate	neutralisation of dichloroisocyanuric acid to form the sodium salt
sodium nitrate (from NOx)	absorption of NOx
sodium pyrithione	nucleophilic substitution of 2-chloropyridine N-oxide with sodium hydrosulfide
stearyldiethanolamine	reaction of 1-octadecylamine and ethylene oxide
styrene-ethylene-butylene-styrene block copolymer (SEBS)	hydrogenation of styrene-butadiene-styrene copolymer
tall oil rosin	fatty acids from crude tall oil
tallow amine	tallow nitrile hydrogenation to primary amine
tallow nitriles	ammoniation-dehydration of fatty acids from tallow with ammonia
technical pentaerythritol (22:3 mix of mono and di for lubricant base stock)	pentaerythritol production without recrystallization
tetradecene-1	fractionation of alpha olefins (SHOP)
tetraethyl lead	reaction of a lead-sodium alloy and ethyl chloride
tetrakis(2,4-di-tert-butylphenyl) 4,4'-biphenylylene diphosphonite	reaction of 2,4-di-tert-butylphenol and phosphorous trichloride and biphenyl
titanium dioxide excluding respirable fraction	titanium dioxide by oxidation of titanium tetrachloride
trichloroisocyanuric acid	full chlorination of dichloroisocyanurate
tricyclodecenol	reaction of dicyclopentadiene and water
tricyclodecenyl acetate	reaction of acetic anhydride and tricyclodecenol
triethyl citrate	reaction of citric acid and ethanol
tris(dicoco-amine-dtc)tris(disulfur-)-thioxotri-molybdenum, salts with 1 eqvivalent N,N-dicocoalkylcarbamodithioates	dicoco MoDTC sulfurized cluster formation

trizinc bis(orthophosphate)	washing, drying and calcinating of zinc phosphate hydrate
vacuum gas oil (>C18), from pyrolysis of mixed waste with caustic soda	pyrolysis of mixed waste with caustic soda
vacuum gas oil (>C18), from pyrolysis of mixed waste with lime	pyrolysis of mixed waste with lime
zinc phosphate hydrate (hopeite)	neutralization reaction of zinc oxide and phosphoric acid