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REPURPOSE

D2.1 Additives' inventory and roadmap of hazardous additives I

(Version 0.5, 27/06/24)

Deliverable description

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Glossary of terms

Ap	Basic diffusion behavior of the polymer matrix in relation to the migrants
BHT	2,6-Di-tert-butyl-p-cresol
BPA	Bisphenol A
CEM	Consumer Exposure Model
Chesar	Chemical safety assessment and reporting tool
CLP	Classification, Labelling and Packaging
CMR	Carcinogens, mutagens or reproductive toxicants
CoRAP	Community rolling action plan
CSS	Chemicals strategy for sustainability towards a toxic-free environment
D	Diffusion coefficient (D, m^2/s).
Dp	Upper-bound diffusion coefficient (m^2/s)
EC	European Comission
ECHA	European Chemicals Agency
ED	Endocrine disruptors
EFSA	European Food Safety Authority
EMKG	Easy-to-use Workplace Control Scheme for Hazardous Substances' tool
ESPR	Ecodesign for Sustainable Products Regulation
EU	Europe or European
EuPC	European Plastic Converters
EUSES	Consumers' exposure estimation
FAIR	Findable, accessible, interoperable and reusable
HCB	Hexachlorobenzene
ILO	International Labour Organisation
JRC	Joint Research Centre
K	Partition coefficient (-)
Kow	Octanol/water partition coefficient
LCA	Life cycle analysis
MS	Member State

MW	Molecular weight of the additive (g/mol)
NAMs	New approach methodologies
ODS	Ozone-depleting substances
OECD	Organisation for Economic Co-operation and Development
PACT	Public activities coordination tool
PAHs	Polycyclic aromatic hydrocarbons
PBT	Persistent, bio-accumulative and toxic
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzo-p-dioxins
PCDFs	Dibenzofurans
PFHxS	Perfluorohexane sulfonic acid
PFNA	Perfluorononanoic acid
PFOS	Perfluorooctanesulfonic acid
PLASI	Plastic additives initiative
PMT	Persistent, mobile and toxic
POPs	Persistent organic pollutants
PVC	Polyvinyl chloride
R	The gas constant (8.3145 J mol−1 K−1)
REACH	Registration, Evaluation, Authorisation and restriction of chemicals. REACH (EC) 1907/2006
RIVM	National Institute for Public Health and the Environment
RMOA	Regulatory Management Option Analysis
RTOs	Research and technology organisations
SC-PAFF	Standing Committee on Plants, Animals, Food and Feed
SMEs	Small and medium size enterprises
SoC	Substances of concern
SSBD	Safe and sustainable by design
SVHC	Substances of very high concern
T	Temperature (K)

TGD	Technical Guidance Document
TRA	Tool developed by the European Centre for ECETOC
UBA	Federal Environment Agency
vPvB	Very persistent and very bio-accumulative
vPvM	Very persistent very mobile
WPL	Work package leader

1. Introduction

This deliverable contains the first part of a report including an inventory of plastics additives, complementary to the ECHA inventory to anticipate future restrictions or interdiction due to safety aspects and hence identify priorities for substitution.

It consists of different tasks which are summarised here briefly:

- Analysis of the main documents published by ECHA related to plastics additives and identification of gaps and main concerns to be tackled including the strategy proposed to solve them.
- Bibliographic research related to plastic additives considered as substances of concern and the study of the most relevant information.
- Complementary study to provide additional information related to the families of additives selected including toxicological and ecotoxicogical databases.
- Eco-design based on the analysis carried out including an in-depth evaluation of the substances to be used for the polymerisation in REPurpose.
- Definition of specifications for the SSBD polymers and comparison of their toxicity with fossil-based counterparts. Output of this task will feed into T2.5, WP5/6.
- Anticipation for future restrictions or interdiction due to safety aspects and hence identification of priorities for substitution.
- Summary of the collaborations established with other granted projects (T8.4) with the target of compiling a global inventory in the end of the project.
- Industry perception related to sustainability and additives used in plastics.

2. Analysis of ECHA documents related to plastic additives

First, an in-depth analysis of the main documents published by ECHA related to plastics additives and the identification of gaps and main concerns to be tackled including the strategy proposed to solve them have been addressed.

2.1. PLASI (plastic additives initiative) & Practical guide for registrants

In late 2016, ECHA and 21 industry sector organisations launched a joint project to characterise the uses of plastic additives and the extent to which the additives may be released from plastic articles. The project lasted for two years until December 2018, and generated an overview of over 400 additives in plastics used in high volumes in the EU, and looked at how use and exposure information could be used to focus the regulatory work by authorities under REACH. It included the development of a method for comparing the release potential of different additives by using some selected parameters.

In response to a request by industry, ECHA has developed a Practical Guide for registrants[1] on how to characterise the uses of additives in plastic materials and how to start estimating the related exposure. In this document, it was defined that about 20% of all registered substances under REACH will become part of an article during their lifecycle and of the materials used to produce articles and buildings, plastics play a prominent role. About 50% of the substances forming part of articles are reported to be hazardous by industry, and therefore require a safety assessment, if produced or imported in amounts of 10 tonnes per year or more. The practical guide specifically addresses exposure (human and environment) to substances in plastic articles when used by consumers, although the methods described can also be applied to the use of articles by workers, when the conditions are similar.

Paragraph 0.3 of REACH Annex I states that "the chemical safety assessment shall consider the use of the substance on its own (including any major impurities and additives), in a mixture and in an article, as defined by the identified uses. The assessment shall consider all stages of the lifecycle of the substance resulting from the manufacture and identified uses", not only the most critical. Therefore, if a substance that fulfils the criteria specified in Article

[1] https://echa.europa.eu/documents/10162/17228/expo_plastic_addives_guide_en.pdf/ef63b255-6ea2-5645-a553-9408057eb4fd

14(4)[2] becomes part of an article, the conditions of safe use during the service and waste operations have to be determined, with the estimation of release and exposure.

The aim of this practical guide is to provide some guiding principles for the chemical safety assessment, addressing substances in or on article matrices and including some advice on:

- how to describe the use as a plastic additive in the registration dossier; and
- how to get started with an exposure assessment for plastic materials.

To configurate this document, the contributions coming from the PLASI and on the findings documented in "Supplementary Information on Scope and Methods",[3] were very relevant.

It is important to highlight that the practical guideline considered does not cover the following aspects:

- Compounding of plastic material and production of articles (and the related occupational exposure).
- Installation and maintenance of articles or complex objects by workers, for example, installing floorings and other virgin materials (potentially releasing substances at a higher rate than during the 'normal' service-life) or maintaining electronic appliances.
- Operations with plastic waste (dismantling of articles and processing plastic waste fractions).
- Communication obligations regarding substances of very high concern in articles.
- Exposure from micro-plastics (*e.g.*, formed by abrasion/degradation of articles contained in consumer products).

To report the uses, the registrants have to consider different aspects, like the technical function, the tonnage and the concept of use maps:

[2] Substances manufactured or imported in quantities of 10 tonnes per year or more (Article 14(1)) that fulfil the criteria for certain hazard classes or categories, or are considered as persistent, bio-accumulative and toxic (PBT) or very persistent and very bio-accumulative (vPvB), the chemical safety assessment has to include additional steps: a) an exposure assessment including the generation of an exposure scenario and b) a risk characterisation for all identified hazards (Article 14(4) of REACH))

[3] https://echa.europa.eu/documents/10162/13630/plastic_additives_supplementary_en.pdf/79bea2d6-8e45-f38c-a318-7d7e812890a1

Technical function

The exposure considerations triggered by the technical functions include, for example:

- Substances acting as slip promoters or anti-statics are meant to move towards the plastic surface and are therefore characterised by a high potential for exposure for this reason.
- Substances acting as coupling agents or cross-linkers (technical function "others") are meant to be reacted into the polymer matrix and, as such, are less likely to be released unless used under (highly) abrasive conditions. The same applies *e.g.*, to flame-retardants polymerised into the matrix.
- Substances acting as plasticisers or flame-retardants are by default expected to be present in higher concentration bands. It is important to mention that when we are talking about the low/high concentrations in plastics does not mean per se low/high release potential because also other chemical properties (*e.g.*, molecular weight, vapour pressure, partition n-octanol water, etc.), the type of matrix (*e.g.*, soft PVC vs rigid PVC) and use conditions need to be taken into account. Exceptions may exist, for example where the polymer itself has already flame-retarding properties.

Tonnage breakdown

ECHA also advises to break down the overall tonnage for a substance into different types of plastic materials/articles, as this may form the basis for the environmental exposure assessment. The differentiation of the tonnage per use at service life stage would be particularly relevant for those articles used indoor and those used outdoor (*e.g.*, roof covers), since they are characterised by a different default release factor.

If no information is available for registrants, worst-case assumptions can be made.

Use maps

Use maps[4] were developed by EuPC (European Plastic Converters) and so far describe uses of plastic additives for formulation (master-batches) and industrial end-use (conversion). This may be a suitable starting point when extending the use map to the article service life stage. Another relevant input to such a use map is the 2019 supplement to the OECD Emission Scenario Document on plastic additives.[5] One of the outcomes of the PLASI project

[4] https://echa.europa.eu/csr-es-roadmap/use-maps/use-maps-library

[5] http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/JM/MONO(2019)10&doclanguage=en

was EuPC's commitment to consider when and how to extend the existing use map (Table 1).[6]

Table 1 - Functions of plastic additives according to OECD 2019.

Additive classification	Additive sub-classification	Description
Additives for processability	Plasticizers	Plasticizers improve the fluidity of plastics during processing and flexibility at room temperature. Used extensively in polyvinyl chloride (PVC) molding.
	Lubricants	Lubricants help prevent the adhesion of plastics to the surface of metal molds and to each other, improve the fluidity of plastics, and reduce friction during melting and molding plastics.
	Blowing agents	Blowing agents, used in foam molding, decompose through heat and compression to produce carbon dioxide, water, nitrogen, and other gases.
Surface protector/ modifier	Antistatic agents	Antistatic agents prevent static electrification of electrical insulators. Classified into coating agents and blending agents. Surfactants are used.
	Antifriction agents	Antifriction agents reduce the surface friction coefficient.
	Adhesion-improving agents	Adhesion-improving agents improve the adhesiveness of the surface of plastics.
	Anti-fog additives	Hydrophobic surfaces permit condensation, leading to loss of translucency. Surfactants prevent fogging.
Material protectants	Antioxidants	Some plastics produce radicals in response to heat and/or light. Antioxidants prevent oxidation and deterioration caused by heat during processing.
	Light stabilizers	Light stabilizers prevent oxidation caused by light during the service life of a plastic product.
	Ultraviolet-absorbing agents	UV-absorbing agents prevent the breakage of molecular bonds by UV light and the generation of radicals.
	Thermo-stabilizers	Thermo-stabilizers inhibit discoloration caused by the HCl produced from vinyl chloride resin because of heat during processing.
Physical-chemical property improvers	Flame retardants	Added to combustible plastics.
	Fillers/reinforcement materials	Various fibers and powders improve the strength of plastics.
Functionalization agents	Coloring agents	Organic or inorganic pigments add color and make plastics light resistant.

In the Appendix of the Practical Guideline the **indicative benchmarks supporting qualitative argumentation** can be found which supports a qualitative argumentation on low potential for release and/or exposure, and being necessary that all them would be fulfilled simultaneously. Only three of them are considered:

- ***Molecular weight: >700 g/mol and Log Kow*** **(octanol/water partition coefficient)** ***>9.***

According to the TGD for Risk Assessment of New and Existing Substances (EC, 2003), certain classes of substances with a molecular mass greater than 700 are unlikely to bio-accumulate significantly (regardless of the log Kow-value). At the level of Log Kow = 9 the bio-magnification factor is set to a minimum value of 1 (R16 ECHA Guidance). According to the Guidance Document on Dermal Absorption (EC, 2004), dermal absorption could be assumed to be <10 % based on physicochemical properties, in particular if MW >500 g/mol and Log Kow >4.5. In this guide it is recommended to make sure that the Log Kow value considered is sufficiently reliable, in particular, with low solubility in both, water and octanol.

6 http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/JM/MONO(2019)10&doclanguage=en

The use of this parameter, the Mw, as an argument, has to keep in mind that the mobility of a substance in a polymer matrix may also depend on its structure, the loading and on the presence of other additives.

- ***Water solubility: 0.01 mg/L.***

It is based on the indicative value used in the Plastic Additive Initiative to determine a group of inorganics and organic pigments reported to have a very low water solubility and in this case, it must be considered that when a low water solubility value is considered, this parameter depends on pH-conditions in the polymer matrix and the water in contact.

- ***Vapour pressure: 10^{-4} Pa.***

It is based on the upper bound for the lowest release band to indoor air set in Tier I model (ECETOC TRA consumer) which is 0.1 Pa. The dependence of this parameter on the temperature of the polymer matrix has to be considered in this case.

Only these three parameters were considered and for this reason, in REPurpose, a broader range of parameters were taken into account, which will be described later.

2.2. Plastic additives initiative Supplementary Information on Scope and Methods (15.02.2019)[7] & Comparison of the relative release potential[8]

To fulfil their specific functions, additives should stay in the plastics they have been added to, but they may nevertheless be released from plastic products during their use. This could result in potential risks to human health and the environment.

For additives, as the object of this document, this parameter depends on:

- Some properties of the substance itself, as the molecular weight.
- Their concentration in the plastic formulation.
- The diffusivity of the polymer matrix.
- The dimensions of the article such as the size of surface.
- The conditions of use of the article, as the temperature, humidity, etc.

[7] https://echa.europa.eu/documents/10162/17228/plastic_additives_supplementary_en.pdf/79bea2d6-8e45-f38c-a318-7d7e812890a1

[8] https://echa.europa.eu/es/comparing-relative-release-potential

For this reason, the producers or developers of additives focus on high quality plastic materials and articles and aim to optimise the combination of these parameters to limit release.

ECHA and industry developed a screening method based on the comparison of relative release potential, to enable the identification of plastic additives that should be prioritised for assessment in the light of available hazard data. An example was included in the report[7] in the form of a table to compare the release potential for a number of organic mono-constituent substances (Table 2). The release indicators quantify the potential of the additive to be released from a particular polymer matrix compared to other additives in the same or different polymer matrix and the higher the figure, the higher the relative potential for release is. For example, a substance with a release indicator value of -2 has a 10-fold release potential compared to a substance with an indicator value of -3. The most restrictive conditions were considered and where industry could not provide information on the typical concentration in a plastic material, a default concentration for the function is used. Where information on the function and/or the polymer matrix was not available, a high default concentration (35%) and a high diffusivity polymer matrix (polyethylene or soft PVC) is used as the default.

In Table 2, substances D, G and M have the highest potentials for release, while substances B, H, I and S have the lowest. This illustrates how the release potential of additives belonging to the same functional group may differ by various orders of magnitude.[8]

Table 2 - Examples for comparing the release potential for organic plastic additives.

Substance name	Molecular weight (Da)	Vapour pressure (Pa)	Water solubility (mg/L)	log Kow (-)	Technical function	Polymeer Matrix	Conc. nn polymer (%)	Release indicator (dermal)	Release indicator (inhalation)
A	403.0	5.63E-04	4.85E-02	5.6	plasticiser	PVC (soft)	35	-2	-2
B	637.0	4.21E-21	2.19E-06	9.61	n.a.	PA	0.5	-7	-10
C	403.0	1.65E-11	1.26E-01	5.12	n.a.	n.a.	35	-2	-8
D	218.0	3.31E-01	5.80E+04	0.36	plasticiser	PVC (soft)	10	0	0
E	795.0	3.28E-22	6.60E-11	13.7	heat stabiliser	Polyolefin-I	2	-6	-9
F	553.0	1.39E-18	2.75E-04	7.79	antioxidant	Polyolefin-I	1	-5	-9
G	255.0	5.93E-16	2.70E+00	-2.28	flame retardant	PUR	30	0	-8
H	685.0	9.51E-14	4.68E-06	10	UV/light stabiliser	PMMA	1	-7	-9
I	593.0	1.06E-15	2.05E-10	14	Other stabiliser	Polyolefin-I	0.3	-7	-10
L	355.0	1.29E-03	1.14E-05	10.2	n.a.	n.a.	35	-4	-3
M	350.0	1.10E-11	2.30E+03	0.51	n.a.	n.a.	35	0	-9
N	214.0	9.48E-06	1.34E+05	-0.19	flame retardant	ABS	25	-3	-4
O	414.0	1.95E-12	2.20E+00	3.57	nucleating agent	Polyolefin-I	2	-3	-9
P	451	9.83E-10	4.97E+01	2.9	UV/light stabiliser	Polyolefin-I	0.8	-3	-8
Q	224.0	6.28E-03	2.33E+02	2.51	Other stabiliser	PVC (soft)	2	-2	-2
R	254.0	2.32E-10	2.80E+03	-2.61	heat stabiliser	Polyolefin-I	2	-1	-5
S	733.0	1.07E-14	2.95E-12	15.1	antioxidant	Polyolefin-I	0.2	-7	-10
T	483.0	4.05E-06	4.78E-08	12	plasticiser	PVC (soft)	35	-4	-4

In the Annex of this document, the methodology applied for determining the relative potential for release of additives from the polymer matrix, the outcome of the sensitivity analysis, and an example of how the comparison of the release potential looks like, is presented.

Parameters to predict the release potential

It is described that the mechanisms driving the releases from a solid (like plastic) matrix to a medium are (Figure 1):

- **Diffusion (D)** of the substance into matrix;
- **Partition (K)** of the substance from matrix surface to a contact medium (*e.g.*, water, saliva, skin, air);
- In some cases, **transport velocity (hm)** between boundary layer and medium (*e.g.*, relevant for air).

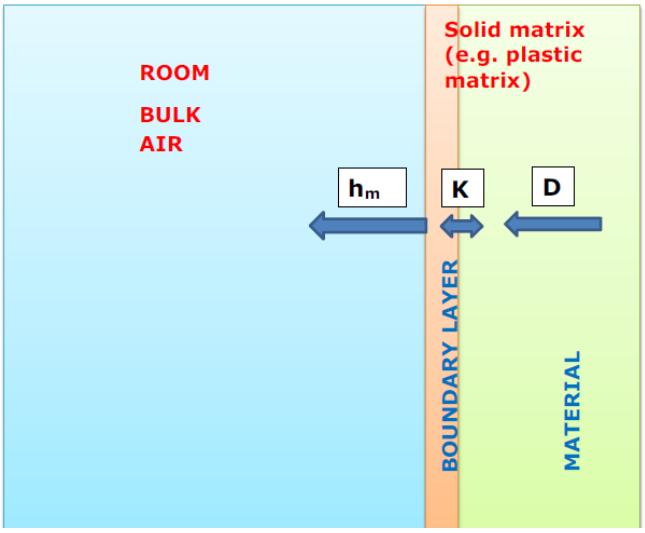


Figure 1 - Mechanisms driving releases from a solid matrix. Source: Plastic additives initiative Supplementary Information on Scope and Methods 15.02.2019.[7]

a) **Diffusion**

The diffusion of the substance in a plastic matrix indicates how fast the substance moves from the matrix itself towards the surface where the mechanism is described by the diffusion coefficient (D, m^2/s). The equation to measure it is based on the JRC Technical Report[9] developed to have a conservative estimation of diffusion of additives in plastic packaging in contact with food and is represented here:

$$Dp^* = \exp[Ap^* - 0.1351 \times MW^{2/3} + 0.003 \times MW - Rx10454/(RxT)]$$

Where:

Dp* = upper-bound diffusion coefficient (m2/s); Ap* = basic diffusion behavior of the polymer matrix in relation to the migrants (* stands as the upper bound for this value); MW = Molecular weight of the additive (g/mol); T = temperature (K); R = the gas constant (8.3145 $J\ mol^{-1}\ K^{-1}$)

Therefore, the diffusion depends on the molecular weight (small molecules move easier in the polymer matrix than large molecules), temperature T (which enhance diffusion) and a coefficient Ap* which depends on the polymer type. Typical values or equations are provided in the JRC Technical Report for different types of plastic matrices and for some polymer types also moisture may play a role.

[9] Practical guidelines on the application of migration modelling for the estimation of specific migration – JRC Technical Report In support of Regulation (EU) No 10/2011 on plastic food contact materials (2015)

b) **Partition**

It defines the partition between the matrix surface and another layer and is defined by a partition coefficient (K, -) representing the ratio between concentration in the plastic matrix at the surface and the concentration in the contact medium. It might be correlated to different substance properties depending on the layer in contact with plastics. In the case of substances in plastic articles, from the perspective of a REACH chemical's safety assessment, these release routes may need to be addressed: to skin, to saliva, to air and to water. In this document it is highlighted that K parameter is far less robust than D, although it is a crucial parameter to estimate release potential from a matrix.[10] To know more details please revise the Plastic additives initiative Supplementary Information on Scope and Methods.[7] It must be highlighted however, that unfortunately for not all the polymer types values are available and therefore assumptions have to be made.

c) **Transport velocity**

For some routes and related to the partition described in "b" (*e.g.*, partition from plastics to air), also the transport velocity (distance per time) of the substance from the material (boundary layer) to the contact medium plays a role which is described by hm, the mass transfer coefficient, expressed as a velocity in m/s. It is recommended to use the equation provided by CEM model.[11] RIVM[12] suggests that values of hm are within a relatively narrow range, *i.e.*, 0.0003-0.005 m/s, so it seems to have little impact on the release rate to air.

d) **Concentration**

The above mechanism (described by the respective coefficients) is (largely) independent on the substance concentration in the matrix. However, the substance concentration always plays a role in the estimation of the release-rate from plastic.

A proportional relationship between release rate and concentration (*i.e.*, half concentration resulting in half release rate) is valid for all release routes.

Continuing with the overview of plastic additives, in this document,[7] 418 substances (

Table *3*) are included belonging to this classification. In total, 58% of them were not under regulatory scrutiny under REACH or CLP (Classification, Labelling and Packaging), 11% remained without any information on their function and 6% had functions that were outside

[10] In the Guideline for a mathematical estimate of the migration of the individual substances from organic material in drinking water, Federal Environment Agency (UBA), 2008, it was suggested values from 0.1 to 1000.

[11] Consumer Exposure Model (CEM) version 2.0 – User Guide, OPPT, USEPA, Risk Assessment Division, 2016.

[12] Emission of chemical substances from solid matrices - A method for consumer exposure assessment, Report 320104011/2010, J.E. Delmaar.

the scope of the project and in the framework of this document (for example lubricants, viscosity modifiers and mold release agents).

Table 3 - Number of substances per function group and proportion of substances under regulatory scrutiny.

Function	No of additives (one function per additive)	Under regulatory scrutiny (%)
Antioxidants	26	65
Antistatics	16	43
Flame retardants	40	67
Nucleating Agents	5	20
Plasticisers	66	54
Pigments	127	30
Heat stabilisers	27	66
UV Stabilisers	16	62
Other stabilisers	23	45
Other functions	72	12
Total number of substances	418	41

After analyzing the information of the documents described in sections 2.1 and 2.2 we have defined these key aspects, gaps and our strategies:

✓ **Analysis of the ECHA Inventory- Key aspects- Gaps**

- ✓ Overview of 418 additives: 58% were not under regulatory scrutiny under REACH or CLP, 11% remained without any information on their function, 6% had functions that were outside the scope of the project (i.e., lubricants, viscosity modifiers and mould release agents).
- ✓ Most critical additives → Comparing relative release potential (Mw, Vapor pressure, H_2O solub., log Kow.)
- ✓ Practical guide describing uses of additives does not cover: compounding, installation & maintenance of articles or complex objects, operations with plastic waste, exposure from micro-plastics (e.g., formed by abrasion/degradation of articles contained in consumer products).
- ✓ Practical guidelines on the application of migration modelling for the estimation of specific migration – JRC Technical Report In support of Regulation (EU) No 10/2011 on plastic food contact materials (2015): lack of information for several polymers.

✓ **REPurpose strategies**

- ✓ Direct contact with companies and associations including AB–most critical additives and exposure scenarios
- ✓ Search of relevant information from toxicity and ecotoxicity Databases
- ✓ Scientific bibliography search
- ✓ Food contact regulation- NIAs
- ✓ Software and QSAR models
- ✓ Toxicologists and ecotoxicologists expertise in the consortium
- ✓ REACH and CLP compliance
- ✓ ...

2.3. Commission Recommendation of 8.12.2022 establishing a European assessment framework for 'safe and sustainable by design' chemicals and materials[13]

The elements of the safe and sustainable by design (SSBD) strategy have only recently been established in an EC recommendation. A lot of interest has been expressed by industry and research and innovation projects are attracting public and private funding.

AIMPLAS prepared a workshop for the REPurpose consortium on the REPurpose 2nd Consortium Meeting, 11-12 October 2023, Vienna, Austria (Figure 2), to share the key points of this Commission Recommendation.

Figure 2 - Picture of the REPurpose 2nd Consortium Meeting, 11-12 October 2023, in Vienna, Austria.

The Recommendation has been generated takingn into consideration the next aspects:

- The EU Green Deal sets out 4 interlinked policy goals for the transition to a sustainable economy and society: climate neutrality, biodiversity protection, circular economy and a zero pollution ambition for a toxic-free environment.
- The EU sustainable finance strategy aims to support the financing of the transition to a sustainable economy.
- The Taxonomy Regulation sets out 4 conditions that an economic activity has to fulfil to qualify as environmentally sustainable. It sets out 6 environmental objectives.

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022H2510

- In the Chemicals Strategy for Sustainability – Towards a Toxic-Free Environment (the 'Chemicals Strategy'), the EC announced that it would develop SSBD criteria' for chemicals & materials.
- The EU Parliament adopted a resolution on the Chemicals Strategy, stressing the need to develop SSBD criteria to prevent and control pollution, improve the tracing of hazardous chemicals in products, and promote their substitution by safer and more sustainable alternatives.
- The Circular Economy Action Plan states that the EC will support substitution and elimination of hazardous substances through R&I.
- The EU Action Plan Towards Zero Pollution for Air, Water and Soil and the Proposal emphasise the commitment to ensure that chemicals & materials are as safe and sustainable as possible by design and during their life cycle.
- A first sector-specific reference to SSBD can be found in the EU Strategy for Sustainable and Circular Textiles, to substitute or minimise SoC (substances of concern).
- A 2020 Eurobarometer survey shows that 84 % of Europeans are worried about the impact on their health of chemicals present in everyday products, and 90 % are worried about chemicals' impact on the environment.
- Several hundred substances have already been identified as SVHC under REACH, and many more could fall under the definition of SoC in the Proposal for a Regulation for setting ecodesign requirements for sustainable products.
- Transition to chemicals & materials that are SSBD requires a common understanding of safety and sustainability to be successful.
- The envisaged framework should make it possible to comprehensively assess the safety and sustainability of chemicals & materials throughout their life cycle and support the design, development, production and use of chemicals & materials that provide a desirable function or service while being safe and sustainable.
- The review of safety and sustainability dimensions, aspects, methods, indicators and tools focuses mainly on chemical safety and environmental sustainability. Assessments of socioeconomic aspects, may be necessary for promoting substitution.
- The aim is to be at the forefront of research and innovation, and to promote use of the latest scientific knowledge.
- The framework should aim to become a global reference for innovation in pursuit of the green industrial transition; for substituting the production and use of SoC; for promoting the use of sustainable resources and feedstock for the production of chemicals & materials; for minimising the impact of the production and use of chemicals & materials, throughout their life cycle, on the climate, on the environment,

and on human health; and for driving industry's and public authorities' R&I investments in the right direction.

- It proposes a European SSBD framework as a point of reference for member states, industry, academia, research and technology organisations (RTOs) and bodies providing benchmarks.
- It sets a testing period for the framework with a voluntary reporting mechanism for MS and stakeholders which must be revised at the latest by the end of the testing period.
- Greater public and private investments in providing safe and sustainable chemicals, and a greater capacity to innovate on the part of the chemicals industry, will be vital for developing new solutions and supporting both the green and digital transitions. The vision for 2030 should therefore ensure that future EU, national and international initiatives are grounded.
- To provide incentives for testing the framework and address SoC, the EC will support the testing period through actions in the Horizon Europe framework programme.
- The EC has also developed a Strategic Research and Innovation Plan to facilitate and support.
- The EC will continue promoting findable, accessible, interoperable and reusable (FAIR) data. It is also developing an EU common data platform on chemicals to facilitate the sharing, access and re-use to existing data.

This Recommendation proposes that a European framework for SSBD chemicals & materials is to be established for R&I activities. The envisaged framework consists of methods for assessing these aspects with the aim that the results obtained will make it possible to define SSBD criteria, including scoring systems and thresholds. It is addressed to MS, industry, including SMEs, academia and RTOs that work on the development of chemicals and materials and encourages to refer to the framework in relevant policy or strategy documents.

It also encourages to report to the EC on the implementation of this Recommendation during the testing period and describes that the EC will make a reporting template available.

In the Annex of this Recommendation, the principles underpinning the SSBD framework are included (Figure 3).

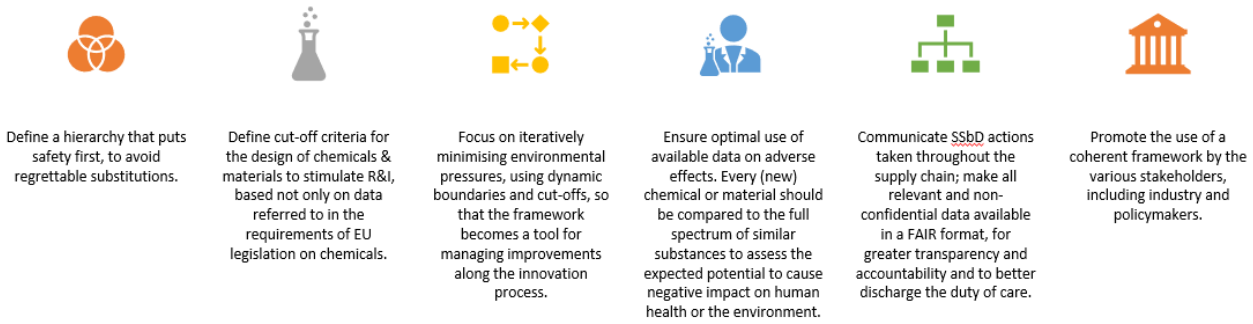


Figure 3 - Principles underpinning the SSBD framework.[13]

The SSBD framework can be applied to the development of new chemicals and materials, or to the re-assessment of existing ones:

i) to support the redesign of their production processes to make them safer and more sustainable by evaluating alternative processes, or

ii) to compare them using the SSBD criteria (*e.g.*, for innovation by substitution with performing chemicals or materials or for selection in downstream applications).

It consists of 2 stages:

i) Stage 1: (re)design stage, and

ii) Stage 2: a safety and sustainability assessment across the different steps in the life cycle of a chemical or material, considering functionality and end-use(s).

It can help with the stages of the innovation process (design, planning, experimental testing and prototyping) where decisions are taken. It should start as early as possible to ensure that SSBD principles are being applied to a chemical's or material's design. After that, the assessment should be done iteratively, at the subsequent stages of development, as more information gradually becomes available. The framework should allow for flexibility in its implementation, to ensure alignment with horizontal or product specific legislations or with regulatory exemptions.

a) Stage 1. The (re)design stage at which guiding design principles are proposed to support the design

(1) molecular design, to design new chemicals and materials based on their chemical structure;

(2) process design, to make the production process safer and more sustainable, both for chemicals and materials being developed and for existing chemicals and materials;

(3) product design, where the results of the SSBD assessment support the selection of the chemicals or materials to meet the functional demands of the final product in which they are used.

b) Stage 2: Safety and sustainability assessment (4 steps) (Figure 4**):**

- ✓ Step 1 – Hazard assessment (intrinsic properties): to understand its hazard profile (human health, environment and physical hazards). REACH and CLP are the most relevant regulations to be considered here. The three main hazard categories are:
  1. intrinsic hazardous properties relevant to human health (human health hazards);
  2. intrinsic hazardous properties relevant to the environment (environmental hazards);
  3. hazard physical properties (physical hazards).

  Classification for SSBD assessment can already consider further hazard classes like: PBT (persistent, bioacummulative and toxic), vPvB (very persistent very bioaccumulative), PMT (persistent, mobile and toxic), vPvM (very persistent very mobile) and ED (endocrine disruptors).

  As the information available for new chemicals/materials could be limited at the beginning, a tiered approach is beneficial to be able to characterise hazards as early as possible by using new approach methodologies (NAMs).
- ✓ Step 2 – Human health and safety aspects of production and processing: assesses the human health and safety aspects of the production and processing of the chemical or material in question. Production means the production process from raw material extraction to production of the chemical or material including recycling or waste management. Goal: assess whether the production and processing poses any risk to workers, in line with, or beyond, EU Occupational Health and Safety directives.

  A tiered approach can be applied to estimate the potential risk of exposure and the expected risk of exposure- ex.: TRA tool developed by the European Centre for ECETOC, Chesar, ILO, German Hazardous Substances Column Model, supported by the 'Easy-to-use Workplace Control Scheme for Hazardous Substances' (EMKG) tool, INRS model, Dutch Stoffenmanager model, Belgian REGETOX model.
- ✓ Step 3 – Human health and environmental aspects in the final application phase: assesses the hazards and risks of the final application to human health or the environment. To estimate exposure, it is important to identify/describe the application and define the use conditions (frequency and duration, amount, conditions and instructions for its use). Recommended to apply ECHA guidance (Chapter R12 Use description21) as a starting point to define the use (categories of use). The chemical safety assessment and reporting tool (Chesar) is another tool recommended. For carrying out the exposure assessment, exposure estimation tools are included: ECETOC TRA tool for workers' and for consumers' exposure estimation, EUSES for environmental exposure estimation. Use maps, developed by industry sectors, collect information on the uses and the conditions of use of chemicals in their sector in a harmonised and structured way. Tools from higher tiers

(ConsExpo) or sector specific tools developed by industry for assessing specific product types and articles, can also be used.

- ✓ Step 4 – Environmental sustainability assessment: along the entire chemical/material life cycle by means of an LCA, assessing several impact categories such as climate change and resource use. Toxicity and ecotoxicity are also considered, referring to impacts due to life cycle emissions to humans and the environment via environmental compartments (*e.g.*, soil, water, air), including mobility between compartments and not via direct exposure (covered in Step 3). The underlying models and characterisation factors, available at https://eplca.jrc.ec. europa.eu/LCDN/developerEF.xhtml, should be applied.

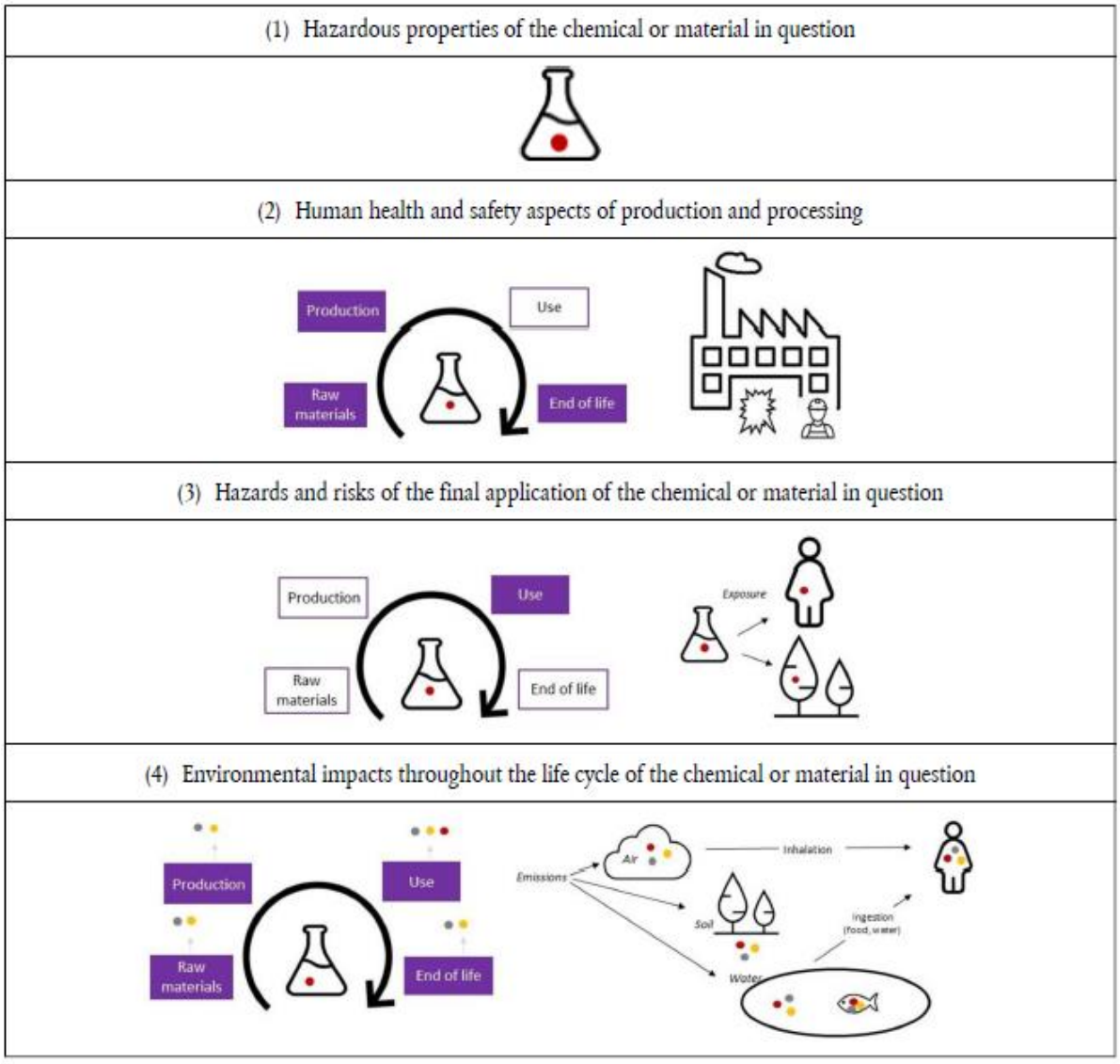


Figure 4 - Illustration of the safety and sustainability aspects of the chemical or material covered by the safety and sustainability assessment. Coloured boxes indicate which life cycle stage is covered. The red dot refers to the chemical or material being assessed, while the yellow and grey dots refer to all the other substances emitted during its life cycle (e.g., other toxic chemicals emitted during the extraction of raw material or as a result of the energy used in the production process). Source: 13.

Based on the recommended data sources to support the safety and sustainability assessment suggested in this Recommendation, we have prepared Figure 5.

Figure 5 - Overview of data sources to support the safety and sustainability assessment.

2.4. EU indicator framework for chemicals[14]

The chemicals strategy for sustainability towards a toxic-free environment (CSS) embraces two overarching goals for chemicals, on the one hand preventing harm to humans and the environment due to hazardous chemicals, and on the other hand supporting EU industry for the production of safe and sustainable chemicals. One of the actions has been materialised in the development of an EU indicator framework on chemicals to monitor the drivers and impacts of chemical pollution and measure the effectiveness. The document was published in February 2024.

The indicator framework is organised according to the elements of the toxic-free hierarchy as specified in the CSS (Figure 6).

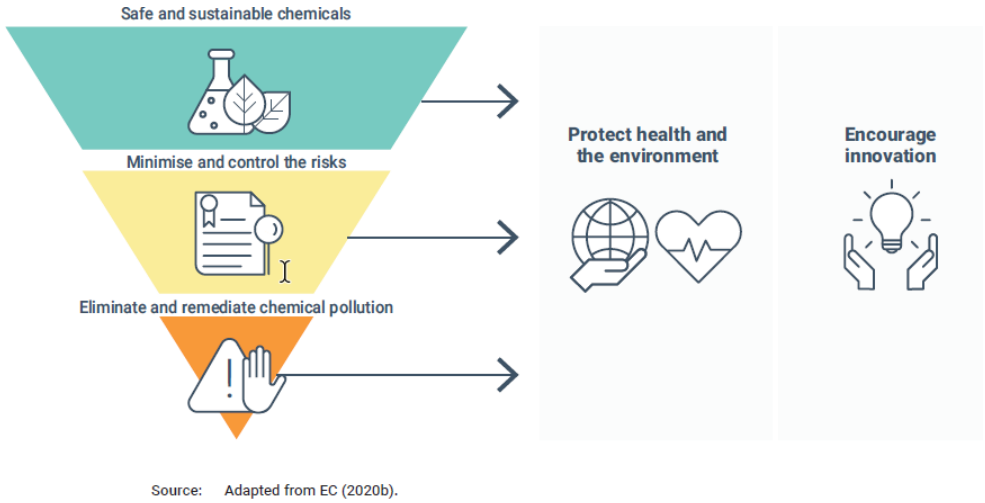


Figure 6 - Toxic-free hierarchy in the chemicals strategy for sustainability. Source: EU indicator framework for chemicals.[14]

[14] https://www.eea.europa.eu/publications/eu-indicator-framework-for-chemicals

It contains the following aspects:

- **Safe and sustainable chemicals**: the developments in this field are progressing in some areas while in others they are just getting started. The elements have been established in an EC recommendation (Section 2.3). Based on the currently available indicators it is difficult to directly measure substitution of the most harmful substances, although the increasing pressure on industry to substitute the most harmful ones has been reflected. The two available indicators on production/consumption and market growth of chemicals suggest that, for CMR category 1 substances, the volumes grew slower than the overall market but there is no significant reduction in the overall use of CMR substances. Related to the consumption of resources, while the gross value added (GVA) of the chemical industry increased by 23% between 2012 and 2020, greenhouse gas emissions decreased by 11% and waste generation in the chemical industry (hazardous and non-hazardous) increased by 7%. Between 2015 and 2020, the total number of uses of experimental animals has remained stable but for specific tests, the uses of experimental animals have significantly decreased.

- **Minimise and control the risks**: The number of industrial chemicals that have come under scrutiny has substantially increased but knowledge gaps remain for a number of substances registered under REACH. Clarity on the hazardous properties of chemicals is the first step. Since entry into force of the CLP, 88 additional chemicals have been identified as carcinogens, mutagens or reproductive toxicants (CMR category 1). Specific evidence from regulating pesticides and substances subject to REACH authorisation shows that the volume of the most harmful substances put on the market can be reduced. Using the grouping approach, it can be possible to accelerate both the assessment and regulatory measures taken on chemicals with structural/functional similarities, as it has happened with per- and polyfluoroalkyl substances (PFAS) and bisphenols. The level of compliance with REACH/CLP obligations has remained relatively high (above 70%) though there has been a slight decrease in compliance in relation to imported goods. For restrictions, a high level of non-compliance is still reported (*e.g.*, presence of phthalates in toys) and for authorisation requirements, an overall non-compliance rate of 40% has been identified.

- **Eliminate and remediate chemical pollution**: there is little evidence of progress towards eliminating substances of concern from waste and secondary materials. Concentrating preventive efforts upstream in the supply chain, at the design and production phases, have to be considered. While waste recycling is improving, there are still some barriers to the recycling of specific wastes such as plastic. There are no

data on the development and implementation of soil and water decontamination techniques. For emissions of certain chemicals to water and air, measures are needed to reach concentration levels that are not harmful. The use of and risk from chemical pesticides have decreased but this decrease has not yet resulted in improvement in environmental quality. The consumption of ozone-depleting substances (ODS) has been phased out since 2010 and the placement on the market of the hydrofluorocarbon greenhouse gases has been substantially reduced since 2015. The emissions to water and air of persistent organic pollutants (POPs) and polycyclic aromatic hydrocarbons (PAHs) have fallen but they have to be lowered more because some pesticides and POPs shown to exceed limit values in water and soil. Human biomonitoring allows to understand human exposure to chemicals and health risks. For some substances, such as bisphenol A and perfluorooctanesulfonic acid (PFOS), internal concentrations exceed safe levels.

Regarding the **main gaps** identified, these ones are mentioned:

- On the occurrence of substances of concern in articles on the EU market and on waste streams. A definition of substances of concern has been included in the Ecodesign for Sustainable Products Regulation. Databases to track substances in waste and secondary raw materials is foreseen and especially for packaging.
- On the number of checks performed by Member States on articles placed on the EU. The newly adopted regulation on general product safety brings the potential for more harmonised checks.
- Currently monitored substances include the so-called 'legacy substances' (chemicals no longer intentionally used) but there is less data on currently used substances.
- Knowledge is lacking on human exposure to and the impacts of many substances and materials, including the combined exposure to different substances (cocktail effect).
- Soil contamination and progress in decontamination techniques are difficult to assess because of a lack of data. The recently proposed soil monitoring law includes the establishment of an EU soil monitoring framework.
- The safe and sustainable by design (SSBD) framework is a new initiative and tools are still under development.

Table 4 - Overview of the EU indicator framework for chemicals: indicators and signals supporting the assessment of progress under the elements of the toxic-free hierarchy.[13]

Safe and sustainable chemicals

11 — 7 indicators, 4 signals

	Safe and sustainable chemicals
Indicators	Growth of the EU chemicals market for substances of different levels of concern
	Number of substances identified as carcinogenic, mutagenic or toxic for reproduction
	Production and consumption of chemicals by hazard class
	Total greenhouse gas emissions in the chemical industry
	Uses of animals by test type in regulatory testing of industrial chemicals
	Uses of animals in regulatory testing of industrial chemicals
	Waste generation in the chemical industry
Signals	Best available techniques (BAT) to cut the use and impact of hazardous chemicals
	Funding EU projects on safe and sustainable chemicals and materials
	Progress in regulating lead
	Safe and sustainable by design chemicals and materials

Minimise and control the risks

16 — 12 indicators, 4 signals

	Minimise and control the risks
Indicators	Alerts for products posing a risk to human health and the environment
	Antimicrobial consumption by food-producing animals in the EU
	CLP controls: percentage of compliant cases found in Member States
	Consumption of ozone-depleting substances
	EU trends in the use and risk of chemical pesticides
	EU trends in the use of more hazardous pesticides
	Human consumption of antibacterials for systemic use in the EU
	Hydrofluorocarbon phase-down in Europe
	Number of substances identified as carcinogenic, mutagenic or toxic for reproduction
	Percentage of REACH CLP-compliant cases found in imported goods
	Progress in regulating substances under REACH and CLP
	REACH controls: percentage of compliant cases found in Member States
Signals	Compliance with REACH restriction and authorisation measures
	Market volume changes of chemicals subject to REACH authorisation
	Progress in regulating lead
	Regulating groups of substances to speed up action and ensure a coherent approach

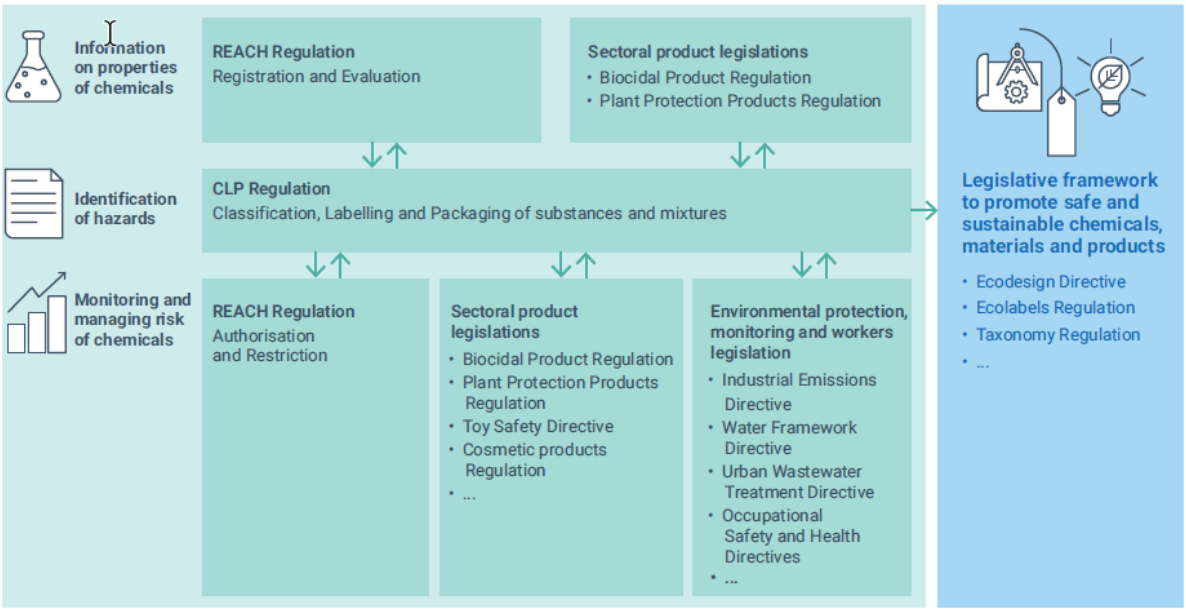
Eliminate and remediate chemical pollution

32 — 16 indicators, 16 signals

	Eliminate and remediate chemical pollution	
Indicators	Alerts for products posing a risk to human health and the environment	Signals
	Antimicrobial consumption by food-producing animals in the EU	
	Consumption of ozone-depleting substances	
	EU trends in the use and risk of chemical pesticides	
	EU trends in the use of more hazardous pesticides	
	Hazardous substances in marine organisms in European seas	
	Human consumption of antibacterials for systemic use in the EU	
	Hydrofluorocarbon phase-down in Europe	
	Industrial chemical releases to air	
	Industrial chemical releases to water	
	Persistent organic pollutant emissions in Europe	
	Pesticides in rivers, lakes and groundwater in Europe	
	Population connected to at least secondary wastewater treatment	
	Production and consumption of chemicals by hazard class	
	Progress in the management of contaminated sites	
	Waste generation in the chemical industry	

Signals	Chemicals in European surface water and groundwater
	Ecological risk of pesticides in EU soils
	Leachate pollution from landfills
	How pesticides impact human health
	Human exposure to bisphenols
	Impacts of microplastics on health
	Long-term impacts of sludge spreading on agricultural land
	Occupational exposure in recycling facilities
	PFAS contamination and soil remediation
	PFAS in European seas
	Plastics recycling in Europe: obstacles and options
	Progress in regulating lead
	Recycling materials from green energy technologies
	Risks of chemical mixtures for human health in Europe
	Risks of PFAS for human health in Europe
	Treatment of drinking water to remove PFAS

In this EU indicator document, the EU legislative framework considers 40 legislative instruments represented by REACH and CLP but also other regulations included in next Figure 7.



Note: REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. A proposal has been submitted for an Ecodesign for Sustainable Products Regulation (ESPR) (EC, 2022c).

Source: EEA.

Figure 7 - Legislative framework for chemicals in the EU.[14]

The drivers and impacts of chemical pollution can be identified at different stages of a chemical's life-cycle (*i.e.*, from manufacture to waste) and relevant areas for each stage (*e.g.*, research and innovation, associated processes and emissions) and mapping the indicators and signals against the different stages of the life-cycle allows to identify the data gaps for certain areas (Figure 8).

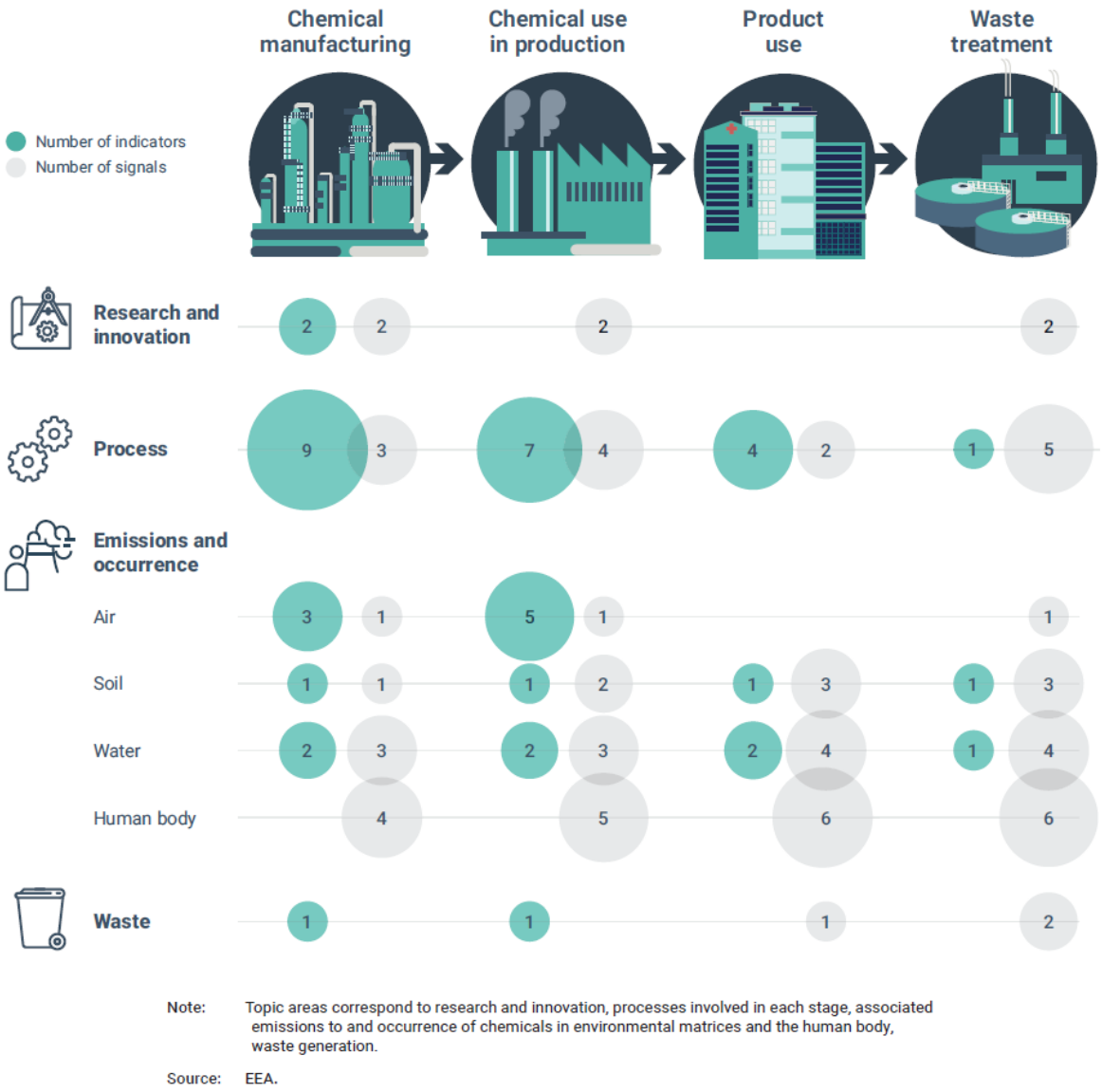


Figure 8 - Mapping of the framework's indicators and signals against the four stages of a chemical's life-cycle and topic areas.[14]

In this document the definition of the terms are included:

- **Hazardous substances** are defined in the CLP Regulation and include all physical, health and environmental hazards. The CSS has introduced two sub-categories: most harmful substances and substances of concern.
- **Most harmful substances** for the substances requiring a generic approach to risk management as a default, in order to ensure that consumers, vulnerable groups, workers and the environment are better protected. They include substances that can cause cancers, gene mutations, affect the reproductive or the endocrine system or are persistent and bioaccumulative, or affecting the immune, neurological or respiratory systems and chemicals toxic to a specific organ.

- **Substances of concern** refers to the ones that have a chronic effect for human health or the environment. They also include those that hamper recycling for safe and high quality secondary raw materials. According to the sustainable product regulation proposal: a) meets the criteria laid down in Article 57 and is identified in accordance with Article 59(1) of REACH; b) is classified in Part 3 of Annex VI to the CLP in one of the following hazard classes or hazard categories: carcinogenicity 1 and 2, germ cell mutagenicity 1 and 2, reproductive toxicity 1 and 2, to be added in the course of the legislative procedure once CLP contains these hazard classes: persistent, bioaccumulative, toxic (PBTs), very persistent very bioaccumulative (vPvBs), persistent, mobile and toxic (PMT), very persistent very mobile (vPvM), endocrine disruption; respiratory sensitisation 1; skin sensitisation 1; chronic hazard to the aquatic environment 1 to 4; hazardous to the ozone layer; specific target organ toxicity – repeated exposure 1 and 2; specific target organ toxicity – single exposure 1 and 2; c) negatively affects the re-use and recycling of materials in the product in which it is present.
- **Substances of very high concern** are defined in REACH as substances that meet the criteria laid down in Article 57 and are in accordance with Article 59(1) of REACH: carcinogenic category 1, mutagenic category 1 and toxic to reproduction category 1, and PBTs, vPvBs or have an equivalent level of concern to substances which are carcinogenic, mutagenic or toxic to reproduction (CMR) and PBT/vPvB.

In addition, the CSS suggests adding all substances which are PMT, vPvM and endocrine disrupters.

Detailed information is given in this document. We consider it relevant to mention again the **emissions of chemicals to air**. The indicator 'Industrial chemical releases to air' shows that point releases of PAHs to air from industry fell by 64% between 2010 and 2022. Meanwhile the indicator 'Persistent organic pollutant emissions in Europe' shows that emissions of hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDDs and PCDFs), and PAHs declined considerably between 2005 and 2021 in the EU, from 15% to 53%. A notable decline in POPs emissions was observed. The Community strategy for PCDDs/PCDFs and PCBs, the POPs Regulation and the IED, have contributed to these substantial reductions. However, the industrial processes and product use sector remains a significant source of POPs (51% of PCBs and 19% of PCDDs and PCDFs, 13% of HCB emissions in 2021). Fuel combustion within this sector is not included in the reporting.

This highlights the importance of designing substances that are SSBD and also ensuring clean production processes to avoid the production of substances of concern upstream and their introduction in products and to the environment.

Regarding the **chemical risks to human health**, there is clear evidence that reducing pollution leads to improved health and wellbeing (EEA, 2020). The **indicator Alerts** for products posing a risk to human health and the environment, introduced earlier, shows that a range of products on the EU internal market still pose chemical health risks for consumers due to the presence of hazardous substances, such as the banned phthalates in non-compliant toys. Certain **endocrine disruptors such as phthalates and bisphenols** are categorised as **substances of very high concern** (ECHA, 2024) due to their impacts on reproduction and development. Phthalates and bisphenols are widely used in the manufacture of plastics to provide the materials with specific properties (*e.g.*, softness and toughness, respectively). The signal Human exposure to **bisphenols** shows that the concentrations of bisphenol A (BPA) in human urine from nine European countries exceed the health-based guidance value established by the European Food Safety Authority (EFSA) in the period 2014-2020. Nevertheless, the data also show a trend towards decreasing BPA levels in urine during this period as a result of different regulatory measures implemented. Two other bisphenols that may be used as alternatives to BPA were also monitored, bisphenol S (BPS) and bisphenol F (BPF). Increasing BPS levels may be an indication of regrettable substitution, as BPS is known to have many of the same concerning properties as BPA.

PFAS, also called 'forever chemicals', refers to a large group of chemical substances that do not break down in the environment and some of them are also known to be bioaccumulative. It was shown that it is not possible to exclude risk for adverse health effects of four PFAS (PFOS, PFOA, perfluorononanoic acid (PFNA), and perfluorohexane sulfonic acid (PFHxS)). Given the large number of PFAS and their widespread use, these results highlight the need for further upstream restrictions of these substances as a group, to limit human exposure to other PFAS not yet regulated.

Some plastics do not degrade in the environment, and they could become fragmented into smaller pieces that can be categorised as **macro-, micro- and nanoplastics**. While there is evidence that microplastics are ubiquitous in the environment and that they may carry substances of concern, there are still many unknowns related to their effects on human health.

Other widespread chemicals that may have adverse effects on human health are **pesticides**. They are out of the scope of this project.

3. Bibliographic research related to plastic additives considered as substances of concern

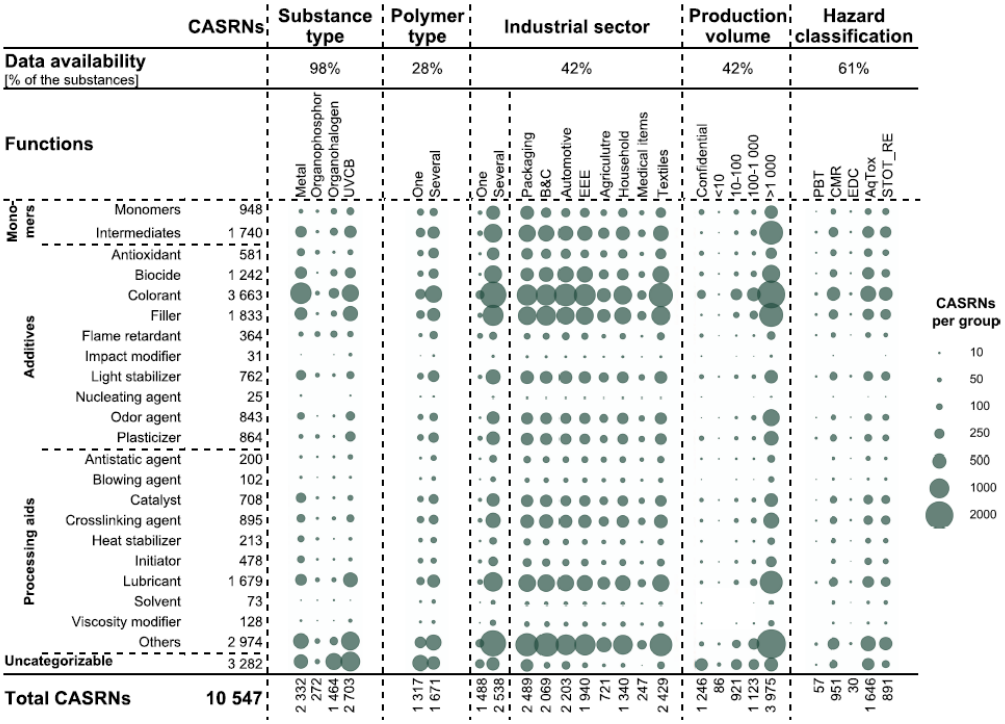
Along the research performed outside the scope of ECHA inventory, an important scientific review[15] was found to include a broad number of additives and monomers with relevant information related to their chemical identities, uses patterns (functions, compatible polymer types, industrial sectors of use, geographical distribution, and production volumes), and reported hazard classifications. Furthermore, based on reported hazard classifications, production volumes, and regulatory status, substances of potential concern were identified. It compiles the work done in 63 industrial, scientific, and regulatory data sources, where more than 10,000 relevant substances were categorised based on substance types, use patterns, and hazard classifications wherever possible, and over 2,400 substances were identified as substances of potential concern as they meet one or more of the persistence, bioaccumulation, and toxicity criteria in the EU. Many of these substances are hardly studied according to SciFinder (266 substances), are not adequately regulated in many parts of the world (1,327 substances) or are even approved for use in food-contact plastics in some jurisdictions (901 substances).

In this work, the substances of potential concern were identified, and a level of potential concern was assigned using a simplified two-step approach, based on hazard classifications and production volumes as surrogate reflecting potentials for causing adverse effects and exposure, respectively. In the first step, substances that fulfill one or more specific hazard criteria under EU REACH were identified as substances of potential concern (Table 5). Substances with insufficient hazard information or without any information at all in the considered regulatory databases were categorised as “unknown”, whereas those with full hazard information but that did not meet any of the considered hazard criteria were categorised as the “low level of concern”. In the second step, depending on production volumes, identified substances of potential concern were either considered the “medium level of concern” (<1000 t/y) or “high level of concern” (>1000 t/y). Identified substances of potential concern were further assessed concerning their regulatory status and the number of scientific references reported in SciFinder.[16]

[15] Environ. Sci. Technol. 2021, 55, 13, 9339–9351.

[16] American Chemical Society (ACS). SciFinder. https://scifinder.cas.org/ (accessed April 15, 2020)

Table 5 – Overview of the substance types, compatible polymer types, industrial sector of use, production volumes, and reported hazard classifications of the identified substances according to their function. The production volume is in tonnes per year (t/y) and represents all uses not just the fraction used in plastics. Data availability is the percentage of substances for which this type of data is available. Intermediates are grouped with monomers, as they are commonly mentioned together. "Others" is an umbrella for many small, ambiguous, or only remotely plastic-related functions. UVCBs =substances of unknown or variable composition, complex reaction products, or biological materials, and simple mixtures, or polymers, B&C = building and construction, EEE = electrical and electronic equipment, PBT = persistence, bioaccumulation, and toxicity, CMR = carcinogenicity, mutagenicity, or reproductive toxicity, EDC = endocrine-disrupting chemicals, AqTox = chronic aquatic toxicity, and STOT_RE = specific target organ toxicity upon repeated exposure.



In general, the following additive families were considered: biocides, colorants, fillers, flame retardants, impact modifiers, light stabilisers, nucleating agents, plasticisers, odor agents, monomers, intermediates, antistatic agents, blowing agents, catalysts, crosslinking agents, heat stabilisers, initiators, lubricants, viscosity modifiers, solvents and other processing aids. As most relevant for the selected applications for polyolefins and polyesters the additives' families we considered: plasticisers, antioxidants and stabilisers (coloration and degradation is common to polyolefins and polyesters), flame retardants, catalysts etc.

In our literature research included in this report, we took into account those plastic additives that are currently on the market and may be relevant for the development of newly developed REP polymers. Thus, mostly biobased and non-biobased compounds which can be applied in polyesters composition were investigated as a reference. This study was focused on finding and collecting toxicological data about these selected additives using toxicological databases and wide literature reviews. The general information included in the

original article was supplemented by data collection on human, aquatic and terrestrial organisms, as well as *In vitro* results where possible.

Based on the data of our toxicological database, it can still (problematically) be stated that there are many plastic additives whose toxicological effects are not described (or published) completely. Moreover in some cases we have not found any relevant measurement results at all.The lack of knowledge about their ecological risk makes it difficult to evaluate the possible environmental effects of these additives on the other. It identifies the research directions that should be followed during the project in order to be able to formulate the advantages of REP polymers compared to the market ready applications.

The database therefore provides the opportunity to select the toxicological methods based on which the properties of our newly developed materials can be compared with the additives used in large quantities. Based on this, we are also able to select the additives that can be used in the newly developed product with the least risk to the environment. As, based on the results, the database is able to find toxicology data gaps, and we can contribute to the creation of new toxicological data regarding individual additives by our measurements and thus contribute to a more detailed understanding of their environmental effects.

4. Complementary study of plastic additives

Based on this document and the expertise of partners with knowledge in this field (MATE, AIM but also Renasci, AVEP and B4P), the selection of the additives involved in polyolefins and polyesters was carried out. Thus, the additives presented in Table 6 and Table 7 were selected to include additional data for both categories, biobased and non-biobased. The second stage was the collection of additional toxicological and ecotoxicological data based on their representativeness and relevance.

Table 6 – Biobased additives used in thermoplastics selected to evaluate additional toxicological and ecotoxicological data.

CAS No	Biobased additive
8013-07-8	Epoxidised soybean oil
67701-03-5	Fatty acids, C16-18
143925-92-2	Amines, bis(hydrogenated tallow alkyl), oxidised
93334-05-5	Fatty acids, montan-wax, sodium salts
68333-92-6	Fatty acids, C7-13, perfluoro
91032-01-8	Fatty acids, C7-19, perfluoro
91052-47-0	Monoglycerides, C16-18
9004-65-3	Cellulose, 2-hydroxypropyl methyl ether
9004-34-6	Cellulose
37205-99-5	Cellulose, carboxymethyl ethyl ether
8001-22-7	Soybean oil
8029-43-4	Hydrolysed starch syrups

9005-25-8	Starch
91722-14-4	Epoxidised soybean oil, acrylate
100209-45-8	Protein hydrolysates, vegetable
68442-85-3	Cellulose, regenerated
9004-35-7	Cellulose, acetate
9012-09-3	Cellulose, triacetate
91079-40-2	Peptones, casein
11132-73-3	Lignocellulose

Table 7 – Non-biobased additives used in thermoplastics selected to evaluate additional toxicological and ecotoxicological data.

CAS No	Non-biobased additive	CAS No	Non-biobased additive
1309-37-1	Iron oxide (Fe_2O_3)	1317-80-2	Rutile (TiO_2)
7439-92-1	Lead	70131-50-9	Bentonite, acid-leached
21645-51-2	Aluminum hydroxide, $Al(OH)_3$)	7723-14-0	Phosphorus
100-21-0	1,4-Benzenedicarboxylic acid	128-39-2	Phenol, 2,6-bis(1,1-dimethylethyl)-
107-21-1	1,2-Ethanediol	504-63-2	1,3-Propanediol
1333-86-4	Carbon black	110-15-6	Butanedioic acid
67-64-1	2-Propanone	111-20-6	Decanedioic acid
79-10-7	2-Propenoic acid	629-11-8	1,6-Hexanediol
1309-42-8	Magnesium hydroxide $Mg(OH)_2$)	7646-85-7	Zinc chloride ($ZnCl_2$)
50-00-0	Formaldehyde	1308-38-9	Chromium oxide (Cr_2O_3)
124-04-9	Hexanedioic acid	14807-96-6	Talc ($Mg_3H_2(SiO_3)_4$)
13463-67-7	Titanium oxide (TiO_2)	646-06-0	1,3-Dioxolane
57-55-6	1,2-Propanediol	7772-99-8	Tin chloride ($SnCl_2$)
7631-86-9	Silica	63231-67-4	Silica gel
7550-45-0	Titanium chloride ($TiCl_4$)	6683-19-8	Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, 1,1'-[2,2-bis[[3-[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl] -1-oxopropoxy] -methyl] -1,3-propanediyl] ester
68333-79-9	Polyphosphoric acids, ammonium salts	31570-04-4	Phenol, 2,4-bis(1,1-dimethylethyl)-, 1,1',1''-phosphite
1332-58-7	Kaolin	13674-84-5	2-Propanol, 1-chloro-, 2,2',2''-phosphate
108-31-6	2,5-Furandione	68333-79-9	Polyphosphoric acids, ammonium salts
1314-13-2	Zinc oxide (ZnO)	57-11-4	Octadecanoic acid
110-63-4	1,4-Butanediol		

The following toxicity databases were used in our study:

- eChemPortal

- US EPA EcoTox knowledgebase
- ChemAgora
- ChemView
- CompTox Chemicals Dashboard
- Consumer Product Information Database Whatsinproducts
- Ecotoxicology Database of NORMAN Substance Database
- PubMed
- MubChem
- NCBI
- WoS
- ATSDR Toxic Substances
- USGS Acute Toxicity
- USDA Food Safety and Inspection Service
- EU National registers of authorised medicines
- FDA Drug Approvals and Databases
- DrugCentral 2021
- DrugBank online
- PPDB: Pesticide Properties Database (Hertfordshire University)
- EnviroTox Database
- TerraToxTM database
- Vlaams Instituut voor de Zee, Platform voor Marien Onderzoek Ecotox database
- Pesticide Action Network – PesticideInfo
- KEGG – Kyoto Encyclopedia of Genes and Genomes
- SIN LIST – Search, explore and Substitute it Now

As a result, a REPurpose inventory has been developed. All collected data were peer reviewed by toxicological experts of MATE. Connected references for the toxicity results of the selected compounds are also given.

5. Evaluation of the substances used in REPurpose and REP polymers eco-design

AIMPLAS and MATE strongly worked together, with the support of REN, B4P and AVEP, to identify the substances that will be used in the project (as REP building blocks, not as additives) and to make an exhaustive study of their toxicological and ecotoxicological data. The identified substances and the full analysis will be presented in D2.2. Moreover, these substances will be experimentally evaluated by MATE on samples provided by AIMPLAS and B4P during the project and will be reported in D2.2.

At the end of the data collection, technical and toxicological data of around 57 different additives, plasticisers and building blocks were collected. Aquatic toxicity data is lacking in several cases, thus it can be stated that the results of the planned toxicological measurements could not only be interesting for the project, but also for scientific or professional experts. It is planned to write a scientific paper about the results of one or some individual products or a review about all the collected results of the database, accordingly, but naturally considering the IPR and dissemination strategy of the project.

The Eco-design concept has been applied as well as the SSBD strategy based on the analysis carried out including an in-depth evaluation of the substances to be used for the polymerisation in REPurpose. In this way, an exhaustive control and monitoring of the REACH and CLP Regulations and any possible alert related to chemicals has been considered from the beginning of the project until now and will be continued along the whole project.

As can be seen in the previous sections, these approaches have been considered and used as the basis for each stage of the development, from the treatment of the waste materials, to the processes and materials used to develop the new building blocks derived from the biomass or enzymatically degraded polyolefin or paper and cardboard waste, to the development of the REP polymers and their processing which is now being evaluated. For the nest steps of the value chain it will be for sure also considered, such as their recycling, transformation into final products for the three selected sectors of application (construction, automotive and consumer goods) including their biodegradation.

This inventory has been used as a basis for the eco-design of all the polymers and products that are being generated in REPurpose.

6. Definition of specifications for the SSBD polymers

The definition of specifications for the REP polymers has been in the same way based on the SSBD framework and the eco-design concepts mentioned previously, always considering these aspects as a priority and requirement for the developments to be carried out.

The comparison of their toxicity with fossil-based counterparts is being performed, and the results will be presented in D5.4.

The specifications are also correlated to the technical and functional properties to be achieved for each one of the applications defined, which will be described in detail in D6.1. Examples of them are the recyclability, biodegradability, durability for construction applications, flexibility/hardness depending on the application, etc.

7. Priorities for substitution identified

The SSBD framework defined in Commission Recommendation (EU) 2022/2510 published on Dec 2022 was applied and has been used along the project progress. REACH updates were followed in detail by AIMPLAS and any modification or related information was communicated to the consortium as to make all partners aware of any possible restriction or limitation and thus anticipate future interdictions due to safety aspects and hence identify priorities for substitution: SVHC, Restriction, CoRAP, PACT, RMOA, Harmonised classifications… This information was shared among partners, stored on the shared folder and explained in the different meetings kept along all the project (WPL meetings, general assembly, etc.). Examples of the information collected to be taken into consideration are any new regulatory requirement or updates related to REACH and CLP Regulations (described in more detail in D2.3 including other regulatory requirements and standards applicable):

2023

- Enforcement authorities to target PFCAs and related substances
- Expert Working Group on Food Contact Materials of the Toxicological Safety
- https://echa.europa.eu/-/echa-recommends-eight-substances-for-reach-authorisation
- The handout of the last meeting of the "Expert Working Group on Food Contact Materials of the Toxicological Safety section of the Standing Committee on Plants, Animals, Food and Feed (SC-PAFF)" on 9th / 10th February 2023 has been published.
- https://single-market-economy.ec.europa.eu/publications/european-critical-raw-materials-act_en
- https://www.europarl.europa.eu/RegData/etudes/STUD/2022/734013/IPOL_STU(2022)734013_EN.pdf
- https://op.europa.eu/en/publication-detail/-/publication/e9e7684a-906b-11ec-b4e4-01aa75ed71a1
- New framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022PC0142
- https://echa.europa.eu/es/-/robust-study-summaries-effectively-support-hazard-assessment
- https://echa.europa.eu/es/-/echa-adds-two-hazardous-chemicals-to-candidate-list
- As reported by EuPC, promoted by Germany, 5 phenolic benzotriazole substances are being investigated as vPvB. The goal is for them to be included in the list of substances of high concern, SVHC. In this case, its restriction or authorisation obligation under REACH would begin to be studied. The specific substances are: UV-234, UV-326, UV-329, UV-P, and UV-928.

- https://echa.europa.eu/es/-/echa-receives-5-600-comments-on-pfas-restriction-proposal RAC and SEAC are evaluating the proposed restriction and considering the relevant information received through the consultation.
- https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AJOL_2023_238_R_0003&qid=1695804976302 Commission Regulation (EU) 2023/2055 of 25 September 2023 amending Annex XVII as regards synthetic polymer microparticles.
- https://echa.europa.eu/es/-/echa-identifies-risks-from-pvc-additives-and microparticle-releases: ECHA identifies risks from PVC additives and microparticle releases
- https://echa.europa.eu/es/-/echa-identifies-research-needs-for-regulating-hazardous-chemicals : ECHA has published a new report on 'Key areas of regulatory challenge 2023' that identifies areas where research is needed to protect people and the environment from hazardous chemicals. It also highlights where new methods, that support the shift away from animal testing, are needed.

2024

- https://echa.europa.eu/es/candidate-list-table : update candidate list of SVHC 23rd Jan 2024.

Nombre de la sustancia expandir/contraer	EC nº	número CAS.	Fecha de inclusión	Motivo de la inclusión	Resolución
Oligomerisation and alkylation reaction products of 2-phenylpropene and phenol Phenol, methylstyrenated EC nº: 270-966-8 | número CAS.: 68512-30-1	700-960-7	-	23-ene-2024	vPvB (Article 57e)	D(2023)8585-DC
Bumetrizole (UV-326)	223-445-4	3896-11-5	23-ene-2024	vPvB (Article 57e)	D(2023)8585-DC
2-(dimethylamino)-2-[(4-methylphenyl)methyl]-1-[4-(morpholin-4-yl)phenyl]butan-1-one	438-340-0	119344-86-4	23-ene-2024	Toxic for reproduction (Article 57c)	D(2023)8585-DC
2-(2H-benzotriazol-2-yl)-4-(1,1,3,3-tetramethylbutyl)phenol (UV-329)	221-573-5	3147-75-9	23-ene-2024	vPvB (Article 57e)	D(2023)8585-DC
2,4,6-tri-tert-butylphenol	211-989-5	732-26-3	23-ene-2024	Toxic for reproduction (Article 57c) PBT (Article 57d)	D(2023)8585-DC

Figure 9 - New update of the candidate list of SVHC (REACH) (23rd Jan 24).

- New substance evaluation conclusion published for CoRAP substance: Diethylmethylbenzenediamine (EC 270-877-4, CAS 68479-98-1) was added to the Community rolling action plan (CoRAP) list in 2016 and evaluated by Denmark: https://echa.europa.eu/es/information-on-chemicals/evaluation/community-rolling-action-plan/corap-table
- Call for evidence: restriction preparation on certain chromium (VI) substances. https://echa.europa.eu/es/applications-for-authorisation-consultation

- Consultations on applications for authorisation: on four applications for authorisation and six review reports covering 13 uses of: chromium trioxide (EC 215-607-8, CAS 1333-82-0), sodium dichromate (EC 234-190-3, CAS 10588-01-9), potassium dichromate (EC 231-906-6, CAS 7778-50-9), arsenic acid (EC 231-901-9, CAS 7778-39-4), 2-ethylhexyl 10-ethyl-4,4-dioctyl-7-oxo-8-oxa-3,5-dithia-4-stannatetradecanoate (EC 239-622-4, CAS 15571-58-1), and tetraethyllead (EC 201-075-4, CAS 78-00-2).
- https://echa.europa.eu/es/applications-for-authorisation-consultation
- New proposals to harmonise classification and labelling. Submitted for: 4-hydroxy-4-methylpentan-2-one; diacetone alcohol (EC 204-626-7, CAS 123-42-2); and 2-amino-2-methylpropanol (EC 204-709-8, CAS 124-68-5).
  https://echa.europa.eu/es/registry-of-clh-intentions-until-outcome
- Nanopinion: Nanoscale KISS method – a novel approach for 2D materials production. https://euon.echa.europa.eu/nanopinion/-/blogs/nanoscale-kiss-method
- EU indicator framework for chemicals — European Environment Agency (europa.eu) (see section 2).

The assistance to **webinars** related to substances limitations or control has also been part of the work done in this sense. As an example, AIMPLAS attended the Fluoropolymers & the PFAs REACH restriction webinar organised by ECHA on the 13th Feb 2023, among others.

As can be seen from these contents and also in previous sections, some families of additives or substances as PFAs, HPAs, bisphenols, phthalates, etc., but also microplastics are pointed and are subjected to a strict control and evaluation processes are ongoing.

It is considered relevant also to mention here the situation of the **flame retardants** (FR) because in the applications tackled in REPurpose these additives are relevant, in particular in the construction and automotive industry. For this reason, an evaluation of their regulatory situation has also been studied.

ECHA has published its regulatory strategy for flame retardants, identifying brominated aromatic flame retardants as candidates for an EU-wide restriction. Thus, regulatory needs for halogenated (including brominated) and organophosphate FRs, which account for 70% of the organic FR market, were identified. Aromatic brominated flame retardants, such as polybrominated diphenyl ethers, are generally persistent in the environment. Many, such as decabromodiphenylether, are also known or suspected to be toxic, accumulating in people and animals. The scope of the restriction could cover all brominated aromatic flame retardants that are or will be confirmed to be PBT or vPvB through harmonised classification or as SVHC. For many brominated aliphatics and some organophosphates, more data is needed to determine if a restriction is necessary along 2024 and it is planned at reassess in 2025. From now, no regulatory action is recommended for several subgroups of non-halogenated flame retardants, including certain organophosphate-based flame retardants, as no or low hazards were identified at this time. For chlorinated flame retardants, regulatory

measures have already been implemented or initiated. REACH restrictions can be initiated by members states or by the European Commission, which can request ECHA to prepare a restriction proposal. The strategy covers ECHA's assessment of regulatory needs for halogenated (including brominated) and organophosphorus flame retardants which was announced in the Restrictions Roadmap under the EU's Chemicals Strategy for Sustainability.

The following aspects are related to the strategy to address the regulatory needs :

- The Commission may introduce eco-design requirements on flame retardants in certain products, as in the Eco-design for Sustainable Products Regulation (ESPR). It foresees the possibility of restricting substances present in products or used in their manufacture that negatively affect their sustainability, including circularity. This route to restrict certain FR may complement, or in certain cases make redundant, the actions proposed to be taken under REACH.
- During the preparation of restriction proposals on flame retardants, the ongoing or planned activities under the Eco-design Directive will need to be considered carefully.
- Further, a critical revision of the different national/EU fire safety standards may be carried out by national authorities or at EU level. Potential changes to fire safety standards may influence the use of flame retardant chemicals in certain product groups.

8. Collaborations with other granted projects with the target of compiling a global inventory

In the framework of collaborations with other granted projects to target a compiled inventory in the end, several partners such as AIMPLAS, ITB, and B4P organised and participated in several meetings and workshops with the other Sister projects as listed below:

- Surpass (04/04/23): exchange of information about inventory of additives (AIMPLAS), platform built and arrangement of meetings (internal and external) for decision-making.
- Estella (19/04/23): AIMPLAS & CIDAUT reach an agreement to prepare a workshop.
- Redondo (22/03/23): meeting at AIMPLAS with the REDONDO coordinator (Figure 10**Error! Reference source not found.**, also shared via LinkedIn) and a follow-up meeting was arranged with AIMEN on (25/04/23).
- SSBD Workshop on (19/10/23) among the four sister projects; Surpass, Redondo, Estella and REPurpose.

- Biobased Nanoadditives in Polymer Composites, REDONDO Workshop (13/06/24): BBEU gave an overview of the first achievements reached in the REPurpose project with the SSBD framework.

Figure 10 - Picture of the meeting hosted by AIMPLAS with Redondo coordinator (22/03/2023).

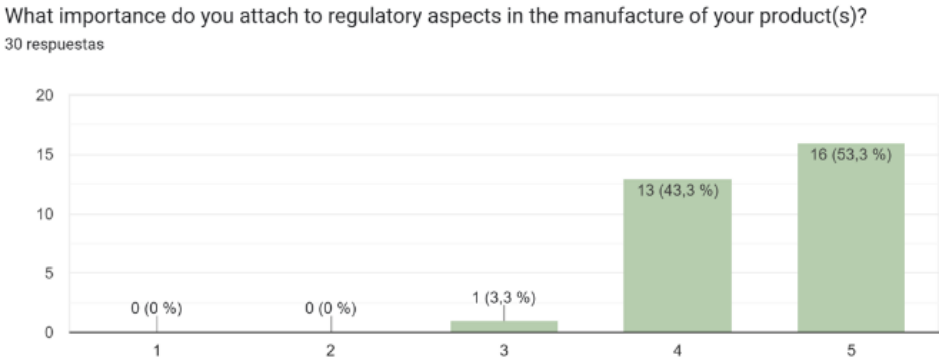
Next events and collaborations have been planned for the second half of this year (2024).

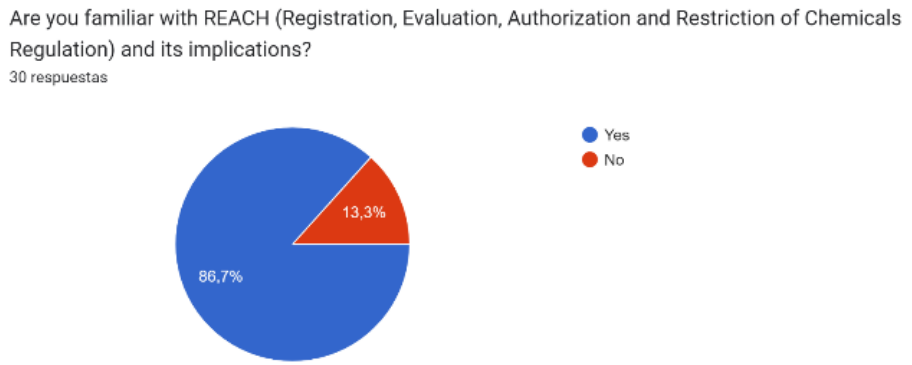
Collaborations to gather and compile information for the additives' inventory were discussed not only with other ongoing projects, but also with companies with expertise in this field. AIMPLAS held several meetings – one of them with a Spanish company, Cadel Recycling (12/04/2023), who configurated an artificial intelligence (AI) based software to assess the contamination/quality of recycled plastics including NIAS (non-intentionally added substances). For now, they developed it for food packaging applications, but the scope could be opened. The meetings were highly interesting, and the company is open to evaluate the materials developed in the REPurpose project.

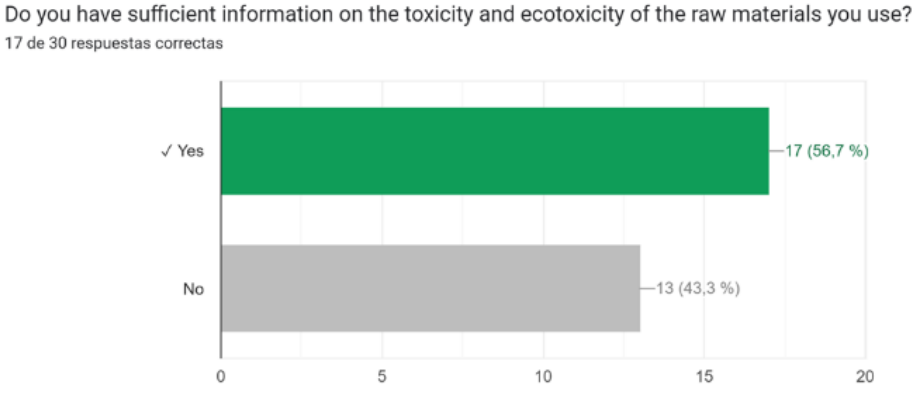
9. Industry perception related to sustainability and additives used in plastics

AVEP prepared a survey in collaboration with AIMPLAS and the rest of the partners involved in this task (B4P, AAU, REN, ITB, BBEPP). The aim was to collect information related to the sustainability strategies that companies are following or would like to follow, and their main concerns in this regard to identify the main bottlenecks and the main interests of the Plastics Industry and related ones, including their concerns with some additives used in plastics. Although the full report will be included in D2.5, we consider it relevant to mentioncertain results. The survey was created in Spanish (https://forms.gle/Lx4kmhWSoGUZeDMK9) and in English (https://forms.gle/4qF74iQTtiXpY4dQ8) and was distributed among companies from different sectors. Up until now 30 surveys have been completed with the main results represented in the next figures. This activity will continue during the entire project period, to achieve as much information as possible about social and industrial concerns, knowledge about the sustainability concepts and main interests, such that the REPurpose project development can be very well aligned with them.

As shown below, most companies consider that the regulatory aspects are quite relevant for the manufacturing of their products, and they are aware of the REACH obligations. Around 57% seems to receive enough information from their suppliers related to toxicity and ecotoxicity of the materials they buy. There are a relevant number of additives they have stopped using due to environmental concerns and they count with alternatives. The use of biobased raw materials is appreciated and more than 65% has used bioplastics. Most of them are also concerned about their end of life and more than 63% of the companies have already defined a sustainability strategy in their company.

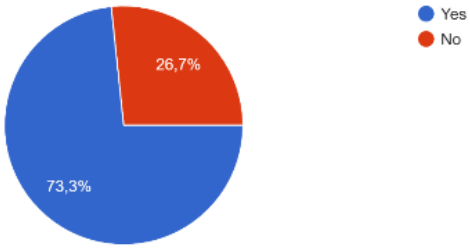






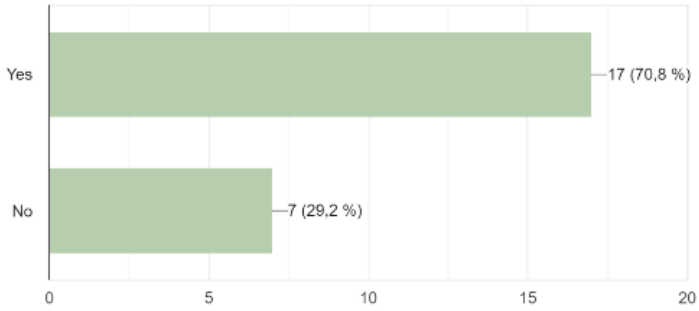
Are there any additives that you have stopped using for environmental reasons or because of a ban?

30 respuestas



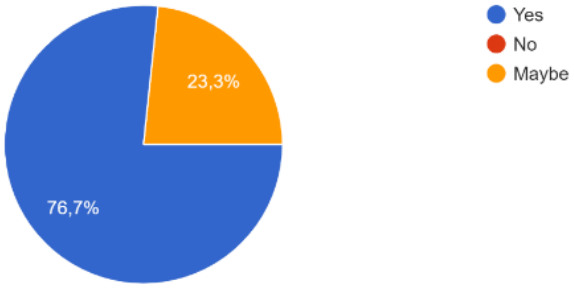
Would they have raw material alternatives in the event of a possible raw material ban?

24 respuestas



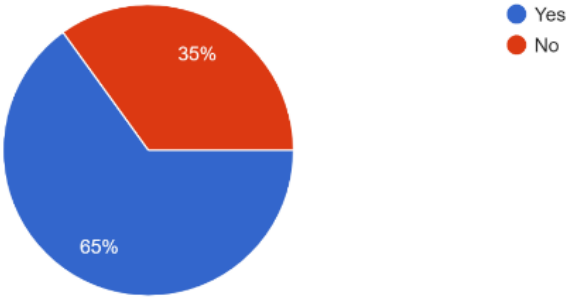
Would you be willing to use raw materials from renewable sources?

30 respuestas



Have you ever worked with Bioplastics?

20 respuestas



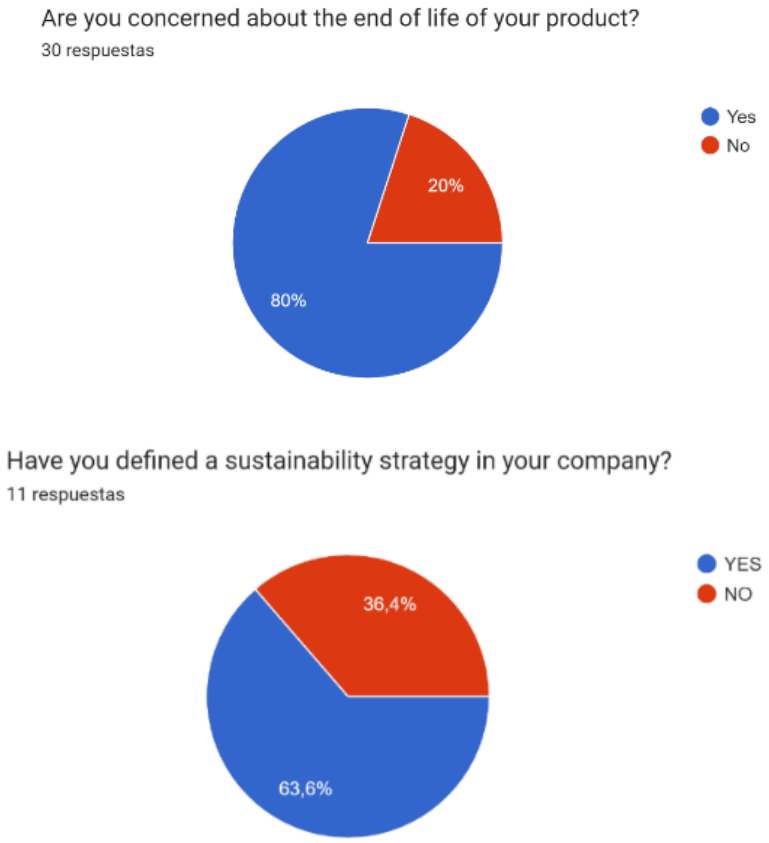


Figure 1111 - Analysis of the answers received from the 30 surveys.

10. Conclusions

In this deliverable relevant information on plastics additives has been collected. Moreover, gaps and lack of information have been identified in relation to the chemicals. REPurpose has provided additional information for some of them. Additionally, REPurpose has identified and applied the main drivers and concepts to work according to the new SSBD and the chemicals strategy for sustainability towards a toxic-free environment (CSS) approaches, for the development of safer and more sustainable polymers and products according to REPurpose objectives.

Annex I - Bibliographic research related to plastic additives considered as substances of concern

In Annex I, the information gathered for the 57 selected sustances is collected.

REPurpose 2023-2024 (substances)			General status (PubChem, CompTox US EPA etc., ECHA Europe, eChemPortal)		
No. of substance	**Substance common name**	**Type of the substance**	**CAS number**	**EC list number**	**IUPAC name**
1.	Epoxidised soybean oil	biobased	8013-07-8	232-391-0	Soybean oil, epoxidised
2.	Fatty acids, C16-18	biobased	67701-03-5	266-928-5	Fatty acids, C16-18
3.	Amines, bis(hydrogenated tallow alkyl), oxidised	biobased	143925-92-2	604-386-7	N,N-dioctadecylhydroxylamine (1)
4	Fatty acids, montan-wax, sodium salts	biobased	93334-05-05	914-479-7 (1)	no data available [2,3]
5.	Fatty acids, C7-13, perfluoro	biobased	68333-92-6 (Example material 335-67-1)	269-801-2 (Example material 206-397-9)	no data available [1] (Example material 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-pentadecafluorooctanoic acid) [6]
6.	Fatty acids, C7-19, perfluoro	biobased	91032-01-8 (Example material 335-67-1)	293-007-5 (Example material 206-397-9)	no data available [3] (Sample material 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-pentadecafluorooctanoic acid) [6]
7	Monoglycerides, C16-18	biobased	85251-77-0	286-490-9	Glycerides, C16-18 mono-and di-
8	Cellulose, 2-hydroxypropyl methyl ether	biobased	9004-65-3	618-389-6	azane;(2S,3R,5S,6R)-2-[(2R,3S,5R,6R)-4,5-dihydroxy-2-(hydroxymethyl)-6-methoxyoxan-3-yl]oxy-6-(hydroxymethyl)-5-methoxyoxane-3,4-diol;methanol;propane-1,2-diol

REPurpose 2023-2024 (substances)			General status (PubChem, CompTox US EPA etc., ECHA Europe, eChemPortal)		
No. of substance	**Substance common name**	**Type of the substance**	**CAS number**	**EC list number**	**IUPAC name**
9	Cellulose	biobased	9004-34-6	232-674-9	(6S)-2-(hydroxymethyl)-6-[(3S)-4,5,6-trihydroxy-2-(hydroxymethyl)oxan-3-yl]oxyoxane-3,4,5-triol
10.	Cellulose, carboxymethyl ethyl ether	biobased	37205-99-5	no data available [1]	no data available [1,2]
11.	Soybean oil	biobased	8001-22-7	232-274-4	no data available [1,2]
12.	Hydrolysed starch syrups	biobased	8029-43-4	232-436-4	(3R,4S,5S,6R)-6-(hydroxymethyl)oxane-2,3,4,5-tetrol;hydrate
13.	Starch	biobased	9005-25-8	232-679-6	no data available [1,2]
14.	Epoxidised soybean oil, acrylate	biobased	91722-14-4	294-415-6	no data available [1,2]
15.	Protein hydrolysates, vegetable	biobased	100209-45-8	309-353-8	no data available [1,2]
16.	Cellulose, regenerated	biobased	68442-85-3	270-493-7	-
17.	Cellulose, acetate	biobased	9004-35-7	618-380-7	[(2R,3S,4S,5R,6R)-5-acetyloxy-3,4,6-trihydroxyoxan-2-yl]methyl acetate [1]
18.	Cellulose, triacetate	biobased	9012.09.03	618-380-7	acetyl 2,3,4,6-tetra-O-acetyl-hexopyranosyl-(1->4)-2,3,6-tri-O-acetyl-hexopyranosyl-(1->4)-2,3,6-tri-O-acetyl-hexopyranoside
19.	Peptones, casein	biobased	91079-40-2	293-428-4	Peptones, casein
20.	Lignocellulose	biobased	11132-73-3	234-384-8	-

REPurpose 2023-2024 (substances)			General status (PubChem, CompTox US EPA etc., ECHA Europe, eChemPortal)		
No. of substance	**Substance common name**	**Type of the substance**	**CAS number**	**EC list number**	**IUPAC name**
21.	Iron oxide (Fe2O3)	non-biobased	1309-37-1	215-168-2	diiron(3+) trioxidandiide
22.	Lead	non-biobased	7439-92-1	231-100-4	Pb
23.	Aluminum hydroxide (Al(OH)3)	non-biobased	21645-51-2	244-492-7	aluminium(3+) trihydroxide
24.	1,4-Benzenedicarboxylic acid	non-biobased	100-21-0	202-830-0	terephthalic acid
25.	Ethylene glycol	non-biobased	107-21-1	203-473-3	ethane-1,2-diol
26.	Carbon black	non-biobased	1333-86-4	231-153-3	carbon black [1]
27.	2-Propanone	non-biobased	67-64-1	200-662-2	acetone, propan-2-one
28.	2-Propenoic acid	non-biobased	1979.10.07	201-177-9	prop-2-enoic acid
29.	Magnesium hydroxide (Mg(OH)2)	non-biobased	1309-42-8	215-170-3	magnesium dihydroxide

REPurpose 2023-2024 (substances)			General status (PubChem, CompTox US EPA etc., ECHA Europe, eChemPortal)		
No. of substance	**Substance common name**	**Type of the substance**	**CAS number**	**EC list number**	**IUPAC name**
30.	Formaldehyde	non-biobased	30525-89-4 [1]	200-001-8 [1]	formaldehyde [1]
31.	Titanium oxide (TiO2)	non-biobased	13463-67-7 [1]	236-675-5 [1]	dioxotitanium [1]
32.	1,2-Propanediol	non-biobased	57-55-6	200-338-0	propane-1,2-diol
33.	Silica	non-biobased	7631-86-9 [1]	231-545-4 [1]	dioxosilane [1]
34.	Titanium chloride (TiCl4) (T-4)-	non-biobased	7550-45-0	231-441-9	titanium tetrachloride
35.	Polyphosphoric acids, ammonium salts	non-biobased	68333-79-9	269-789-9	undecaammonium bis(phosphonatooxy)phosphinate dihydrogen phosphate hydrogen (phosphonatooxy)phosphonate hydrogen phosphate
36.	Kaolin	non-biobased	95077-05-07 [1]	310-194-1 [1]	oxo-oxoalumanyloxy-[oxo(oxoalumanyloxy)silyl]oxysilane dihydrate [1] , other name is: bolus alba [2]
37.	2,5-Furandione	non-biobased	108-31-6	203-571-6	furan-2,5-dione

REPurpose 2023-2024 (substances)			General status (PubChem, CompTox US EPA etc., ECHA Europe, eChemPortal)		
No. of substance	**Substance common name**	**Type of the substance**	**CAS number**	**EC list number**	**IUPAC name**
38.	Zinc oxide (ZnO)	non-biobased	1314-13-2 [1]	215-222-5 [1]	oxozinc [1]
39.	Octadecanoic acid	non-biobased	1957.11.04	200-313-4	stearic acid
40.	Hexadecanoic acid	non-biobased	1957.10.03	200-312-9	palmitic acid
41.	Rutile (TiO2)	non-biobased	13463-67-7 [1]	236-675-5 [1]	dioxotitanium [1]
42.	Bentonite, acid-leached	non-biobased	70131-50-9	274-324-8	Bentonite, acid-leached
43.	Phosphorus	non-biobased	7723-14-0	918-594-3	phosphorus
44.	Phenol, 2,6-bis(1,1-dimethylethyl)-	non-biobased	128-39-2	204-884-0	2,6-ditert-butylphenol
45.	1,3-Propanediol	non-biobased	504-63-2	207-997-3	propane-1,3-diol
46.	Decanedioic acid	non-biobased	111-20-6	203-845-5	decanedioic acid

REPurpose 2023-2024 (substances)			General status (PubChem, CompTox US EPA etc., ECHA Europe, eChemPortal)		
No. of substance	**Substance common name**	**Type of the substance**	**CAS number**	**EC list number**	**IUPAC name**
47.	Zinc chloride (ZnCl2)	non-biobased	7646-85-7	231-592-0	zinc dichloride
48.	Chromium oxide (Cr2O3)	non-biobased	1308-38-9	215-160-9	chromium (III) oxide
49.	Talc (Mg3H2(SiO3)4)	non-biobased	14807-96-6 [2]	238-877-9 [2]	Dioxosilane oxomagnesium [1]
50.	1,3-Dioxolane	non-biobased	646-06-0	211-463-5	1,3-dioxolane
51.	Tin chloride (SnCl2)	non-biobased	7772-99-8	231-868-0	tin dichloride [1] dichlorotin [5]
52.	Silica gel	non-biobased	112926-00-8	231-545-4	dioxosilane
53.	Benzenepropanoic acid	non-biobased	501-52-0	207-924-5	3-Phenylpropanoic acid
54.	Phenol, 2,4-bis(1,1-dimethylethyl)-, 1,1',1''-phosphite	non-biobased	31570-04-04	250-709-6	Tris(2,4-di-tert-butylphenyl)phosphite
55.	2-Propanol, 1-chloro-, 2,2',2''-phosphate	non-biobased	13674-84-5	237-158-7	tris(2-chloro-1-methylethyl) phosphate

REPurpose 2023-2024 (substances)			General status (PubChem, CompTox US EPA etc., ECHA Europe, eChemPortal)		
No. of substance	**Substance common name**	**Type of the substance**	**CAS number**	**EC list number**	**IUPAC name**
56.	Polyphosphoric acids, ammonium salts	non-biobased	68333-79-9	269-789-9	undecaammonium bis(phosphonatooxy)phosphinate dihydrogen phosphate hydrogen (phosphonatooxy)phosphonate hydrogen phosphate
57.	Cis,cis-muconic acid	biobased	1119-72-8	628-830-4	(2Z,4Z)-hexa-2,4-dienedioic acid

1. **Epoxidised soybean oil (CAS 8013-07-8)**

   General information: Biobased type plastic additive with unknown molecular weight as it has variable compositions. Water solubility: 20ng/liter (20°C), and -2.15°C melting point. Unknown persistency level and bioaccumulation.

   Human Toxicity: CLP hazard not classified. Carcinogenity, genotoxicity, mutagenicity: no classification is warranted. OECD 471, 473 and 476 resulted negative. Reproductive/developmental toxicity is negative in rats (1000 mg/kg bw/day was found to be the NOEL). No skin and eye irritation and sensitising. Acute oral toxicity (mammals): >5000 mg/kgbw (partially nontoxic) and >20ml/kgbw (partially nontoxic) dermal toxicity.

   Aquatic toxicity: Acute algal toxicity: EC50 8mg/liter, NOEC: 0,7mg/l.

   Terrestrial Toxicity: Earthworm NOEC= 1000mg/kg soil dry weight. Soil microbes: 7d EC50= 76.6 mg/kg soil dw, 14d EC50= 169 mg/kg soil dw, 28d EC50= 402 mg/kg soil dw, NOEC= 62.5 mg/kg soil dw

   In vitro toxicity: No data

   References:

   https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15408/7/3/2

2. **Fatty acids, C16-18 (CAS 67701-03-5)**

   General information: Biobased type plastic additive with unknown molecular weight as it has variable compositions. Water solubility: >0.05ng/liter (20°C), and 55°C melting point. Unknown persistency level and bioaccumulation.

   Human Toxicity: CLP hazard not classified. Carcinogenity not classified. Genotoxicity, mutagenicity: chromosomal aberration in Cellosaurus cell lines was negative. No adverse effect in reproductive/developmental toxicity (NOAEL>1000 mg/kg bw/d). No skin irritation and sensitising. Slightly eye irritating. Acute oral toxicity (mammals): >5000 mg/kgbw (partially nontoxic). Acute dermal toxicity (mammals): LD50>2000mg/kgbw. Acute inhalation toxicity (mammals): LC50>0.162 mg/l.

   Aquatic toxicity: Acute fish toxicity: EC50 >1000mg/liter. Daphnia acute toxicity EC50: 4.8mg/l. Aquatic invertebrates: EC50>0.22mg/l. Algae acute (72h) toxicity: EC50> 0.9mg/l.

   Terrestrial Toxicity: *Pseudomonas putida*: EC10 = 883mg/kg.

   In vitro toxicity: No data.

   References:

   https://echa.europa.eu/sl/registration-dossier/-/registered-dossier/15426/1/1

3. **Amines, bis(hydrogenated tallow alkyl), oxidised (CAS 143925-92-2)**

General information: Biobased type plastic additive with 537.99g/mol molecular weight. Insoluble in water, and have 96-99°C melting point. Unknown persistency level and bioaccumulation.

Human Toxicity: CLP hazard not classified. No information about carcinogenity nor genotoxicity, and mutagenicity. No adverse effect in reproductive/developmental toxicicity. No skin and eye irritation and sensitising.

Aquatic toxicity: No published data.

Terrestrial Toxicity: No published data.

In vitro toxicity: No data

References:

[1] https://www.bocsci.com/product/amines-bis-hydrogenated-tallow-alkyl-cas-143925-92-2-49831.html

[2] https://www.alfa-chemistry.com/irgastab-fs-042-cas-143925-92-2-item-67262.htm

[3] https://echa.europa.eu/hu/information-on-chemicals/cl-inventory-database/-/discli/details/116732 (3) https://pubchem.ncbi.nlm.nih.gov/compound/Amines_-bis_hydrogenated-tallow-alkyl_-oxidised#section=Information-Sources

[4] https://echa.europa.eu/hu/information-on-chemicals/pbt-vpvb-assessments-under-the-previous-eu-chemicals-legislation

4. **Fatty acids, montan-wax, sodium salts (CAS 93334-05-05)**

General information: Unknown.

Human Toxicity: No available data

Aquatic toxicity: No published data.

Terrestrial Toxicity: No published data.

In vitro toxicity: No data

References:

[1] https://watchdog.ecomole.com/en/listitem/93634/

[2] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.070.247

[3] https://pubchem.ncbi.nlm.nih.gov/compound/Fatty-acids_-montan-wax_-zinc-salts#section=Names-and-Identifiers

5. **Fatty acids, C7-13, perfluoro (CAS 68333-92-6)**

General information: Biobased type plastic additive with 414.07g/mol molecular weight. Solubility in water: 3300mg/l, and have 3.2°C melting point. Persistent organic compound (PoP)

Human Toxicity: CLP hazard not classified. No information about carcinogenity nor genotoxicity, and mutagenicity. No adverse effect in reproductive/developmental toxicicity. No skin and eye irritation and sensitising.

Aquatic toxicity: No published data.

Terrestrial Toxicity: No published data.

In vitro toxicity: No data

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/Fatty-acids_-C7-13_-perfluoro;
[2] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.063.436;
[3] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.084.520;
[4] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.005.817;
[5] https://echa.europa.eu/documents/10162/8059e342-1092-410f-bd85-80118a5526f5;
[6] https://pubchem.ncbi.nlm.nih.gov/compound/Perfluorooctanoic-acid;
[7] https://www.sciencedirect.com/science/article/pii/S026974912100511X?via%3Dihub;
[8] https://www.sciencedirect.com/science/article/pii/S0887233317302825#s0075;
[9] https://www.tandfonline.com/doi/full/10.3109/1547691X.2012.755580;
[10] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2860088/;
[11] https:/pubmed.ncbi.nlm.nih.gov/6636169/;
[12] https://www.tandfonline.com/doi/abs/10.1081/DCT-39707;
[13] https://www.tandfonline.com/doi/abs/10.1080/10408440490464705;
[14] https://onlinelibrary.wiley.com/doi/abs/10.1002/tox.20396;
[15] https://www.jstage.jst.go.jp/article/jhs/56/1/56_1_104/_article/-char/ja/;
[16] https://analyticalsciencejournals.onlinelibrary.wiley.com/doi/full/10.1002/jat.1736;
[17] https://link.springer.com/article/10.1007/s11356-016-6285-1;
[18] https://pubmed.ncbi.nlm.nih.gov/20451658/

6. **Fatty acids, C7-13, perfluoro (CAS 91032-01-8)**

General information: Biobased plastic additives with no defined molecular weight. Solubility in water: 3300 mg/L, and have 3.2 °C melting point. Persistent organic pollutant (POP).

Human toxicity: CLP hazard not classified. No information about carcinogenity or genotoxicity, and mutagenicity. No adverse effect in reproductive/developmental toxicity. No skin and eye irritation and sensitizing.

Aquatic toxicity: No published data.

Terrestrial toxicity: No published data.

In vitro toxicity: No published data.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/Fatty-acids_-C7-13_-perfluoro.;
[2] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.063.436;
[3] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.084.520;
[4] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.005.817;
[5] https://echa.europa.eu/documents/10162/8059e342-1092-410f-bd85-80118a5526f5;
[6] https://pubchem.ncbi.nlm.nih.gov/compound/Perfluorooctanoic-acid;
[7] https://www.sciencedirect.com/science/article/pii/S026974912100511X?via%3Dihub;
[8] https://www.sciencedirect.com/science/article/pii/S0887233317302825#s0075;
[9] https://www.tandfonline.com/doi/full/10.3109/1547691X.2012.755580;
[10] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2860088/;
[11] https://pubmed.ncbi.nlm.nih.gov/6636169/;
[12] https://www.tandfonline.com/doi/abs/10.1081/DCT-39707;

[13] https://www.tandfonline.com/doi/abs/10.1080/10408440490464705 ;
[14] https://onlinelibrary.wiley.com/doi/abs/10.1002/tox.20396;
[15] https://www.jstage.jst.go.jp/article/jhs/56/1/56_1_104/_article/-char/ja/;
[16] https://analyticalsciencejournals.onlinelibrary.wiley.com/doi/full/10.1002/jat.1736;
[17] https://link.springer.com/article/10.1007/s11356-016-6285-1;
[18] https://pubmed.ncbi.nlm.nih.gov/20451658/

7. **Monoglycerides, C16-18 (CAS 85251-77-0)**

General information: Biobased plastic additives, with undefined molecular weight. Practically insoluble in water, melting point: 56 °C. Compound is readily biodegradable in water (100%).

Human toxicity: CLP hazard classification: H412. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation. Acute oral toxicity (mammals): no adverse effects (LD50 2000 mg/kg bw). Dermal toxicity (mammals): no adverse effects (LD50 2000 mg/kg bw). Inhalation toxicity (mammals): no adverse effects (LC50 1.86 mg/L air)

Aquatic toxicity: Acute fish toxicity: LC0 (4 days): 10 g/L. Chronic *Daphnia* toxicity: 10 µg/L. No acute or chronic toxicity to fish, low toxicity to aquatic invertebrates and algae.

Terrestrial toxicity: No published data.

In vitro toxicity: No data.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/
[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/

8. **Cellulose, 2-hydroxypropyl methyl ether (CAS 9004-65-3)**

General information: Biobased plastic additive with 495.5 g/mol molecular weight. Soluble in water. No information available on persistency/bioaccumulation.

Human toxicity: CLP hazard classification: H372; H335. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation. Acute oral toxicity (mammals): no adverse effects (LD50 4000 mg/kg/day).

Aquatic toxicity: No published data.

Terrestrial toxicity: No published data.

In vitro toxicity: No data.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/

[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/
[5] https://doi.org/10.1016/j.fct.2007.07.011

9. Cellulose (CAS 9004-34-6)

General information: Biobased plastic additive with 342.3 g/mol molecular weight. Insoluble in water, melting point: 260 °C. Completely biodegradable.

Human toxicity: CLP hazard classification: H301; H302; H312; H314; H315; H319; H332; H335; H412. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation. Acute oral toxicity (mammals): LD50 5000 mg/kg (not toxic). Dermal toxicity (mammals): LD50 2000 mg/kg (not toxic). Inhalation toxicity (mammals): LC50 5800 mg/L (not toxic).

Aquatic toxicity: No published data.

Terrestrial toxicity: No published data.

In vitro toxicity: No data.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/
[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/
[5] https://doi.org/10.1016/j.fct.2007.07.011
[6] https://doi.org/10.1111/j.1574-6976.1994.tb00033.x

10. Cellulose, carboxymethyl ethyl ether (CAS 37205-99-5)

General information: Biobased plastic additive, with no defined molecular weight. Soluble in water. Can be expected to be degraded completely in natural environmental systems such as soils, lakes, and rivers.

Human toxicity: CLP hazard classification: not classified. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation.

Aquatic toxicity: Acute toxicity to fish: LC0 (4 days) 2.5 g/L. Acute *Daphnia* toxicity: NOEC 5 g/L.

Terrestrial toxicity: No published data.

In vitro toxicity: Cytotoxicity: NOEC 96h 0.5-1 g/L.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/
[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/
[5] https://doi.org/10.1002/etc.5620150307

11. **Soybean oil (CAS 8001-22-7)**

General information: Biobased plastic additive, with no defined molecular weight. Insoluble in water, melting point: 22-31 °C. Readily biodegradable in water, soil.

Human toxicity: CLP hazard classification: H319; H413. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation.

Aquatic toxicity: No published data.

Terrestrial toxicity: No published data.

In vitro toxicity: No data.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/
[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/

12. **Hydrolysed starch syrups (CAS 8029-43-4)**

General information: Biobased plastic additive, with 198.17 g/mol molecular weight. No information available on water solubility and melting point. Completely biodegradable.

Human toxicity: CLP hazard classification: not classified. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation. Acute oral toxicity (mammals): no adverse effects (LD50 10000 mg/kg).

Aquatic toxicity: No published data.

Terrestrial toxicity: No published data.

In vitro toxicity: genotoxicity/mutagenicity: bacterial mutagenesis E. coli WP2 UVRA, *S. typhimurium* TA98 positive.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/
[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/
[5] https://doi.org/10.3390/su14106085

13. **Starch (9005-25-8)**

General information: Biobased plastic additive, with no defined molecular weight. No information available on water solubility and melting point. Completely biodegradable.

Human toxicity: CLP hazard classification: H319; H320; H332; H335; H411. No information available on carcinogenicity, genotoxicity, mutagenicity and

reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation.

Aquatic toxicity: No published data.

Terrestrial toxicity: No published data.

In vitro toxicity: No data.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/
[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/
[5] https://doi.org/10.3390/su14106085

14. Epoxidised soybean oil, acrylate (CAS 91722-14-4)

General information: Biobased plastic additive, with no defined molecular weight. Water solubility: 291 mg/L, melting point: -20 °C. Inherently biodegradable in water (100%)

Human toxicity: CLP hazard classification: H315; H317; H319. No information available on carcinogenicity. Genotoxicity/mutagenicity (mammals): no adverse effects (negative). Reproductive/developmental toxicity (mammals): no adverse effects (NOAEL 1000 mg/kg bw). Not sensitizing or irritating to eyes/skin/respiratory system. Acute oral toxicity (mammals): no adverse effects (LD50 5000 mg/kg bw). Acute dermal toxicity (mammals): no adverse effects (LD50 2000 mg/kg bw).

Aquatic toxicity: Acute fish toxicity: LC50 100 mg/L. Acute *Daphnia* toxicity: EC50 100 mg/L. Algae acute toxicity: EC50 100 mg/L. Not acutely hazardous to aquatic environments.

Terrestrial toxicity: No published data.

In vitro toxicity: mutagenicity/genotoxicity negative.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/
[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/
[5] https://doi.org/10.3390/su14106085

15. Protein hyrdrolysates, vegetable (CAS 100209-45-8)

General information: Biobased plastic additive, with no defined molecular weight. Water solubility: 786 g/L, melting point: 241.2 °C. No information available on persistency and biodegradability.

Human toxicity: CLP hazard classification: H319. No information available on carcinogenicity and reproductive/developmental toxicity. Genotoxicity/mutagenicity (non-mammalian): *Drosophila* mutagenesis and chromosome aberration positive. No

data available on skin/eye/respiratory sensitisation and irritation. Acute oral toxicity (mammals): practically nontoxic (LD50 2000-5000 mg/kg bw).

Aquatic toxicity: No published data.

Terrestrial toxicity: No published data.

In vitro toxicity: genotoxicity/mutagenicity: bacterial Mutagenesis *S. tyohimurium* TA 1535 positive; cytogenetics other *S. cerevisiae* positive.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/

[2] https://comptox.epa.gov/dashboard/

[3] https://chemview.epa.gov/chemview/#

[4] https://pubchem.ncbi.nlm.nih.gov/

16. Cellulose, regenerated (CAS 68442-85-3)

General information: Biobased plastic additive, with no defined molecular weight. No information available on water solubility, melting point, persistency and biodegradability.

Human toxicity: CLP hazard classification: not classified. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation.

Aquatic toxicity: No published data.

Terrestrial Toxicity: No published data.

In vitro toxicity: No data.

References:

[1] https://echa.europa.eu/hu/information-on-chemicals/cl-inventory-database/-/discli/details/46459;

[2] https://comptox.epa.gov/dashboard/chemical/executive-summary/DTXSID1098547;

[3] https://pubchem.ncbi.nlm.nih.gov/compound

17. Cellulose, acetate (CAS 9004-35-7)

General information: Biobased plastic additive, with 264.23 g/mol molecular weight. No information available on water solubility, melting point, persistency and bioaccumulation.

Human Toxicity: CLP hazard classification: not classified. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation.

Aquatic toxicity: No published data.

Terrestrial Toxicity: No published data.

In vitro toxicity: No data.

References:

[1] https://www.alfa-chemistry.com/product/cellulose-acetate-cas-9004-35-7-165908.html;

[2] https://echa.europa.eu/hu/information-on-chemicals/cl-inventory-database/-/discli/details/119709;
[3] https://chemview.epa.gov/chemview/#;
[4] https://comptox.epa.gov/dashboard/chemical/executive-summary/DTXSID401010898;
[5] https://pubchem.ncbi.nlm.nih.gov/compound/Cellulose%20Acetate#section=Toxicity

18. Cellulose, triacetate (CAS 9012-09-3)

General information: Biobased plastic additive, with 966.8 g/mol molecular weight. No information available on water solubility, melting point, persistency and bioaccumulation.

Human toxicity: CLP hazard classification: not classified. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation.

Aquatic toxicity: No published data.
Terrestrial toxicity: No published data.
In vitro toxicity: No data.
References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/Cellulose-triacetate;
[2] https://chemview.epa.gov/chemview/#;
[3] https://comptox.epa.gov/dashboard/chemical/executive-summary/DTXSID30892177;
[4] https://chemview.epa.gov/chemview/#

19. Peptones, casein (CAS 91079-40-2)

General information: Biobased plastic additive, with no defined molecular weight. Water solubility: 8.82-28.96 g/L. No information available on melting point, persistency and bioaccumulation
Human Toxicity: CLP hazard classification: not classified. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation.
Aquatic toxicity: No published data.
Terrestrial Toxicity: No published data.
In vitro toxicity: No data.
References:

[1] https://comptox.epa.gov/dashboard/chemical/executive-summary/DTXSID901020218;
[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/13755/2/1;
[3] https://echa.europa.eu/hu/information-on-chemicals/cl-inventory-database/-/discli/notification-details/32179/944423 ;
[4] https://pubchem.ncbi.nlm.nih.gov/#query=91079-40-2 ;

20. Lignocellulose (CAS 11132-73-3)

General information: Biobased plastic additive, with no defined molecular weight. No information available on water solubility, melting point, persistency and bioaccumulation.

Human Toxicity: CLP hazard classification: not classified. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on skin/eye/respiratory sensitisation and irritation.

Aquatic toxicity: No published data.

Terrestrial Toxicity: No published data.

In vitro toxicity: No data.

References:

[1] ChemView ;

[2] https://comptox.epa.gov/dashboard/chemical/executive-summary/DTXSID8093948 ;

[3] https://pubchem.ncbi.nlm.nih.gov/substance/135323881#section=Names-and-Synonyms;

[4] https://echa.europa.eu/hu/information-on-chemicals/cl-inventory-database/-/discli/details/97579

21. Iron oxide Fe2O3 (CAS 1309-37-1)

General information: Non-biobased plastic additive, with 159.69 g/mol molecular weight. Insoluble in water, melting point: 1565 °C. No information available on persistency and biodegradability.

Human Toxicity: CLP hazard classification: not classified. IARC Group 3 - Not classifiable as to its carcinogenicity to humans. No information available on genotoxicity, mutagenicity and reproductive/developmental toxicity. No data available on respiratory sensitisation and irritation. Not sensitizing or irritating to skin/eye. Acute oral toxicity (mammals): no adverse effects (LD50 2000 mg/kg bw). Acute dermal toxicity (mammals): no adverse effects (LD50 2000 mg/kg bw). Acute inhalation toxicity (mammals): no adverse effects (LC50 5 mg/L air).

Aquatic toxicity: Acute fish toxicity: LC0 10-100 mg/L. Acute Daphnia toxicity: EC50 100 mg/L. Chronic Daphnia toxicity: NOEC 20 mg/L. Acute algal toxicity: EC50 20 mg/L. No acute or chronic hazard identified to aquatic environment.

Terrestrial Toxicity: No published data.

In vitro toxicity: Genotoxicity/mutagenicity: positive for DNA damage/repair in rats.

References:

[1] https://echa.europa.eu/hu/brief-profile/-/briefprofile/100.013.790;

[2] https://comptox.epa.gov/dashboard/chemical/genotoxicity/DTXSID0029632?deepLink=13;

[3] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15552/6/1

22. Lead (CAS 7439-92-1)

General information: Non-biobased plastic additive, with 207.2 g/mol molecular weight. Water solubility: 185 mg/L, melting point: 326 °C. The criterion for persistence and bioaccumulation are not applicable for inorganic Pb.

Human Toxicity: CLP hazard classification: GHS08; H360; H362; H372. IARC Group 2B - Possibly carcinogenic to humans; B2 (U.S. EPA) - probable human carcinogen. No information available on genotoxicity/mutagenicity. Reproductive/developmental toxicity: concentrations > 1.1 mg of lead influenced the loss of epididymal weight and the damage in epididymal tissue and sperm parameters. Neurotoxicity: Chronic low-level lead exposure triggers microglial activation, leading to the release of TNF-α. This, in turn, induces ferroptosis in hippocampal neurons via the dysregulation of iron metabolism and the Nrf2-dependent ferroptosis pathway. No data available on skin/eye/respiratory sensitisation and irritation. Acute oral toxicity (mammals): no adverse effects (LD50 2000 mg/kg bw). Acute dermal toxicity (mammals): no adverse effects (LD50 2000 mg/kg bw). Acute inhalation toxicity: no adverse effects (LC50 5 mg/L air).

Aquatic toxicity: Acute fish toxicity: LC50 (4 days) 0.04-40 mg/L. Chronic fish toxicity: NOEC (52 days) 0.126 mg/L. Acute *Daphnia* toxicity: LC50 0.026-3.115 mg/L. Chronic *Daphnia* toxicity: NOEC (30 days) 0.014-0.031 mg/L. Toxicity to sediment dwelling organisms: NOEC (28 days) 503 - 4719 mg/kg sediment dry weight. Toxicity to aquatic plants: EC50 1.07 - 8.53 µM. Acute algal toxicity: EC50 0.02-0.36 mg/L. Chronic algal toxicity: NOEC (4 days): 0.022-0.192 mg/L. Data is conclusive but not sufficient for acute or chronic hazard classification to aquatic environment.

Terrestrial toxicity: Microorganism toxicity: IC50 (9 h) 180 mg/L; EC10 (24 h) 7 mg/L. Acute bird toxicity: Long-term EC10 / LC10 / NOEC 100 mg/kg food.

In vitro toxicity: No data.

References:

[1] https://echa.europa.eu/hu/brief-profile/-/briefprofile/100.028.273;
[2] https://comptox.epa.gov/dashboard/chemical/properties/DTXSID2024161;
[3] https://chemview.epa.gov/chemview/#;
[4] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/16063/2/1 ;
[5] https://doi.org/10.1016/j.chemosphere.2021.133020;
[6] https://doi.org/10.1016/j.scitotenv.2024.170317;

23. Aluminum hydroxide AlOH3 (CAS 21645-51-2)

General information: Non-biobased plastic additive, with 81 g/mol molecular weight. Insoluble in water, melting point: 300 °C. Estimated persistence in water, soil, or sediment is high, with half-life of 60-180 days.

Human Toxicity: CLP hazard classification: not classified. IARC classified aluminum production as carcinogenic to humans (Group 1), but did not implicate aluminum itself

as a human carcinogen. Genotoxicity/mutagenicity negative for chromosomal aberrations and gene mutations, no structural alerts. Reproductive/developmental toxicity is low (>1000 mg/kg/day). Moderately neurotoxic (10-100 mg/kg/day oral). Aluminum targets the nervous system and causes decreased nervous system performance and is associated with altered function of the blood-brain barrier. The accumulation of aluminum in the body may cause bone or brain diseases. High levels of aluminum have been linked to Alzheimer's disease. A small percentage of people are allergic to aluminium and experience contact dermatitis, digestive disorders, vomiting or other symptoms upon contact or ingestion of products containing aluminium. Seizures, osteomalacia, and encephalopathy are well-documented toxic effects of aluminum hydroxide. Patients should be asked about any kidney issues before aluminum hydroxide administration, as these outcomes have strong correlations with aluminum hydroxide's use as a phosphate binder in patients on dialysis. No data available on skin/eye/respiratory sensitisation and irritation. Data is conclusive but not sufficient for classification on acute oral, dermal and inhalation toxicity to mammals.

Aquatic toxicity: Acute fish toxicity: LC50 0.078-218.6 mg/L. Chronic fish toxicity: NOEC 0.088-2.3 mg/L. Acute *Daphnia* toxicity: EC50 0.071-99.6 mg/L. Toxicity to aquatic plants: no toxicity observed (NOEC > 45.7). Acute algal toxicity: EC50 0.024-4.93 mg/L. Moderate acute and chronic hazard to aquatic environment.

Terrestrial Toxicity: No published data.

In vitro toxicity: No data.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15529/2/1;
[2] https://chemview.epa.gov/chemview/#;
[3] https://echa.europa.eu/hu/brief-profile/-/briefprofile/100.040.433;
[4] https://pubchem.ncbi.nlm.nih.gov/compound/6328211#section=Toxicity-Summary;
[5] https://www.ncbi.nlm.nih.gov/books/NBK546669/#:~:text=Seizures%2C%20osteomalacia%2C%20and%20encephalopathy%20are,binder%20in%20patients%20on%20dialysis.

24. 1,4-Benzenedicarboxylic acid (CAS 100-21-0)

General information: Non-biobased plastic additive, with 166.13 g/mol molecular weight. Water solubility: 17 mg/L, melting point: 427 °C. Not persistent and is readily biodegradable.

Human toxicity: CLP hazard classification: not classified. Terephthalic acid has been found to arrest cell proliferation and promote resistance to a specific type of apoptosis in human breast cells, suggesting that it is a possible carcinogen. Feeding terephthalic acid to rats increased the number of rats with tumors. Feeding terephthalic acid to rats, 50 mg/kg was enough to cause single hyperplasia, 500

mg/kg was enough to cause atypical hyperplasia, and 5,000 mg/kg was enough to cause ‘‘bladder transitional cell cancer’’. Dietary administration of up to 20000 ppm TPA for two successive generations did not result in any effects on reproductive performance. (rat, OECD 416). Teraphtalic acid changes the reproductive parameters (testicular weight, GI, penis size, and anogenital index) only at the dose of 0.56 g/ml in male mice. Terephthalic acid on testicular functions of rats, male Sprague–Dawley rats were orally administered TPA in diet at the levels 0.2, 1 and 5% for 90 days. Damages of spermatogenic cells and Sertoli cells were observed by electron microscope, testicular sperm head counts, daily sperm production, and activities of sorbitol dehydrogenase (SDH) were decreased significantly in the 5% TPA group. No information available on genotoxicity, mutagenicity. Terephtalic acid can mildly irritate the respiratory tract, and can irritate the eyes. Not irritating or sensitizing to skin. Acute oral toxicity (mammals): no adverse effects (LD50 >15380 mg/kg bw). Acute dermal toxicity (mammals): no adverse effects (LD50 2000 mg/kg bw). Acute inhalation toxicity (mammals): no adverse effects (LC50 2.02 mg/L air).

Aquatic toxicity: Acute *Daphnia* toxicity: NOEC 20.1 mg/L. Chronic *Daphnia* toxicity: NOEC 19.5 mg/L. Acute algal toxicity: NOEC 19.0 mg/L. Data is conclusive but not sufficient for acute and chronic hazard classification to aquatic environment.

Terrestrial Toxicity: Microorganism toxicity: EC50 (3h) 1392.8 mg/L.

In vitro toxicity: Cytotoxicity: The test substance is negative in the mouse micronucleus test. Genotoxicity/mutagenicity: The test substance produced no mutagenic effects using *In vitro* and in vivo mutagenic test systems (Ames, Chromosome Aberration, and Micronucleus).

References:

[1] https://echa.europa.eu/hu/brief-profile/-/briefprofile/100.002.573;
[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15563/2/1;
[3] https://chemview.epa.gov/chemview/#;
[4] https://comptox.epa.gov/dashboard/chemical/details/DTXSID6026080;
[5] https://doi.org/10.1080/15287390701432277 ;
[6] https://doi.org/10.1007/s11356-023-26849-x;
[7] https://doi.org/10.1016/j.tox.2004.03.024;
[8] https://doi.org/10.1248/cpb.16.1655;
[9] https://doi.org/10.1016/j.jchas.2016.09.005;

25. Ethylene glycol (CAS 107-21-1)

General information: Non-biobased plastic additive, with 62.07 g/mol molecular weight. Miscible with water, melting point: -13 °C. Readily biodegradable in water (100%).

Human toxicity: CLP hazard classification: H302; H315; H319; H332; H335; H336; H340; H360; H370; H372; H373; H412. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. No data

available on respiratory sensitisation and irritation. Not irritating or sensitizing to skin/eye. Acute oral toxicity (mammals): adverse effect observed (LD50 7712 mg/kg bw). Acute dermal toxicity (mammals): adverse effect observed (LD50 3500 mg/kg bw). Acute inhalation toxicity: adverse effect observed (LC50 2.5 mg/L air).

Aquatic toxicity: Acute fish toxicity: LC50 49000-72860 mg/L. Chronic fish toxicity: NOEC 40 mg/L. Acute *Daphnia* toxicity: EC50 100 mg/L. Chronic *Daphnia* toxicity: NOEC 8590-24000 mg/L. Acute crustacean toxicity: LC50 50000 mg/L. Toxicity to aquatic plants: EC50 10920 mg/L. Acute algal toxicity: EC50 100 mg/L. Chronic algal toxicity: NOEC 10940 mg/L. Not acutely or chronically hazardous to the aquatic environment.

Terrestrial Toxicity: No published data.

In vitro toxicity: Cytotoxicity threshold >10000 mg/L. Genotoxicity/mutagenicity: negative.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/
[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/

26. Carbon black (CAS 1333-86-4)

General information: Non-biobased plastic additive, with 12.01 g/mol molecular weight. Insoluble in water, melting point: 3625 °C. It is concluded that carbon black is not a PBT/vPvB substance.

Human toxicity: CLP hazard classification: H351; H335; H373; H319; H372; H370; H413; H410; H411; H252; H251; H228; H332. Based on available data, the substance does not meet the classification criteria on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. Irritating to the eyes, skin and respiratory system. Acute oral toxicity (mammals): LD50 >15400 mg/kg. Acute inhalation toxicity (mammals): LC0 >4.6 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 >5000 mg/L. Acute *Daphnia* toxicity: EC50 >5600 mg/L. Acute algal toxicity: EC50 >10000 mg/L.

Terrestrial toxicity: Microorganism toxicity: EC10 800 mg/L.

In vitro toxicity: No data.

References:

[1] https://pentacarbon.de/wp-content/uploads/2023/09/MSDS_N-Types_2021_ENG.pdf
[2] https://www.chemicalbook.com/ProductChemicalPropertiesCB3109508_EN.htm
[3] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.014.191
[4] https://echa.europa.eu/hu/information-on-chemicals/cl-inventory-database/-/discli/details/13192

27. 2-Propanone (CAS 67-64-1)

General information: Non-biobased plastic additive, with 58.08 g/mol molecular weight. Miscible with water, melting point: -94.8 °C. Not persistent.

Human Toxicity: CLP hazard classification: H225; H319; H336. Not classifiable as to human carcinogenicity. No information available on genotoxicity, mutagenicity. Indications of developmental toxicity in mice and rats (reduction of fetal weights, increase of late resorptions) were only observed at exposure concentrations that induced significant maternal toxicity, so that a classification is not justified according to EC regulation 1272/2008. Exposure of pregnant rats to 0, 440, 2200 and 11000 ppm acetone did not result in selective developmental toxicity. Maternal toxicity was evident at the high exposure level of 11000 ppm as decreases in body and uterine weight. At this dose level a significant decrease of fetal weight indicated fetal toxicity. There was no indication of a teratogenic potential (NOAEL 11000 ppm). No data available on skin/respiratory sensitisation and irritation. Causes serious eye irritation. Acute oral toxicity (mammals): LD50 5800 mg/kg. Acute dermal toxicity (mammals): LD50 7400 mg/kg. Acute inhalation toxicity (mammals): NOAEC 19000 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 5.54-11.0 g/L. Acute *Daphnia* toxicity: LC50 8800 mg/L. Chronic *Daphnia* toxicity: NOEC 2212 mg/L. Not acutely or chronically hazardous to the aquatic environment.

Terrestrial Toxicity: Acute earthworm toxicity: 0.1-1 mg/cm^2. Microorganism toxicity: EC10 1000 mg/L.

In vitro toxicity: Not mutagenic/genotoxic.

References:

[1] https://echa.europa.eu/hu/brief-profile/-/briefprofile/100.000.602
[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15460/2/1;
[3] https://comptox.epa.gov/dashboard/chemical/details/DTXSID8021482;
[4] https://chemview.epa.gov/chemview/#

28. 2-Propenoic acid (CAS 1979-10-7)

General information: Non-biobased plastic additive, with 72.06 g/mol molecular weight. Miscible with water, melting point: 13 °C. Not persistent.

Human toxicity: CLP hazard classification: H226; H302; H312; H332; H314; H335; H400. Data is conclusive but not sufficient for carcinogenicity classification. Acrylic acid did not induce gene mutations in *Salmonella typhimurium* or CHO cells (HGPRT locus) but was positive in the mouse lymphoma assay and in the *In vitro* chromosomal aberration test. Since in the mouse lymphoma assay preferentially small colonies were induced, the mutagenic potential of acrylic acid seems to be limited to clastogenicity. No reproductive/developmental toxicity observed. No data available on respiratory sensitisation and irritation. Corrosive to skin and causes irreversible

effects on the eye. Acute oral toxicity (mammals): LD50 1000-2000 mg/kg bw. Acute dermal toxicity (mammals): LD50 >2000mg/kg bw. Acute Inhalation toxicity (mammals): LC50 5.1 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 222 mg/L. Acute *Daphnia* toxicity: EC50 95 mg/L. Chronic *Daphnia* toxicity: NOEC 19 mg/L. Acute crustacean toxicity: LC50 97 mg/L. Acute algal toxicity: EC50 0.13 mg/L. Chronic algal toxicity: NOEC <0.13 mg/L. Both acutely and chronically hazardous to the aquatic environment.

Terrestrial toxicity: Acute earthworm toxicity: LC50 >1000 mg/kg dry weight. Microorganism toxicity: concentrations of acrylic acid up to 100 ppm were non-toxic to the soil micro-flora, while a concentration of 1000 ppm was highly toxic.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15803;
[2] https://pubchem.ncbi.nlm.nih.gov/compound/Acrylic-acid

29. Magnesium hydroxide MgOH2 (CAS 1309-42-8)

General information: Non-biobased plastic additive, with 58.32 g/mol molecular weight. Water solubility: 1.78 mg/L. No information on persistency and biodegradability.

Human toxicity: CLP hazard classification: H302; H315; H317; H318; H319; H332; H335. Not warrant classification for carcinogenicity. No genotoxicity, mutagenicity and reproductive/developmental toxicity was observed. Not irritating or sensitizing to skin/eye/respiratory system. Acute oral toxicity (mammals): LC50 >2000 mg/kg bw. Acute inhalation toxicity (mammals): LC50 >2.1 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 >100 mg/L. Acute *Daphnia* toxicity: EC50 >100 mg/L. Acute algal toxicity: EC50 >100 mg/L. Not acutely hazardous to the aquatic environment.

Terrestrial Toxicity: No published data.

In vitro toxicity: Magnesium hydroxide had little or no effect on the mitotic index of lymphocyte cultures, a measure of cytotoxicity. Not genotoxic/mutagenic.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/16073/4/1,
[2] https://pubchem.ncbi.nlm.nih.gov/compound/Magnesium-Hydroxide

30. Formaldehyde (CAS 30525-89-4)

General information: Non-biobased plastic additive, with 30.03 g/mol molecular weight. Miscible with water, melting point: -92 °C. Not persistent.

Human toxicity: CLP hazard classification: H301; H311; H314; H317; H318; H330; H331; H341; H350; H351. Classified as Carcinogen 1B (18.33%) and Carcinogen 2 (65.2%).

Suspected of causing genetic defects. An investigation of reproductive function in female workers exposed to formaldehyde in the garment industry revealed increased incidence of menstrual disorders, inflammatory disease of the reproductive tract, sterility, anemia, and low birth weights among offspring. Functional and molecular network analysis of the predicted miRNA transcript targets revealed that formaldehyde exposure potentially alters signalling pathways associated with cancer, inflammatory response, and endocrine system regulation. Formaldehyde has pathological effects on neurons. Formaldehyde is toxic if inhaled, causes skin corrosion, severe skin burns and eye damage. Acute oral toxicity (mammals): LD50 460 mg/kg bw (moderately toxic). Acute inhalation toxicity (mammals): LC50 454 mg/L (practically nontoxic).

Aquatic toxicity: No published data.

Terrestrial toxicity: No published data.

In vitro toxicity: Positive genotoxicity/mutagenicity in high doses.

References:

[2] https://echa.europa.eu/hu/information-on-chemicals/pbt-vpvb-assessments-under-the-previous-eu-chemicals-legislation
[3] https://echa.europa.eu/hu/information-on-chemicals/cl-inventory-database/-/discli/details/55163 [4] https://echa.europa.eu/nl/substance-information/-/substanceinfo/100.000.002
[5] https://pubchem.ncbi.nlm.nih.gov/compound/712#section=Toxicity
[6] https://echa.europa.eu/documents/10162/cc0acabf-6e82-f2ed-5dbe-8058f48ce6c4

31. Titanium oxide TiO2 (CAS 13463-67-7)

General information: Non-biobased plastic additive, with 79.87 g/mol molecular weight. Insoluble in water, melting point: 1855 °C. A PBT assessment is obsolete as the criteria for persistence are not applicable, no relevant bioaccumulation exists.

Human Toxicity: CLP hazard classification: H351. Titanium dioxide is possibly carcinogenic to humans (Group 2B). No information available on genotoxicity, mutagenicity and reproductive/developmental toxicity. It may cause respiratory irritation, causes skin irritation and serious eye irritation. Acute oral toxicity (mammals): LD50 >10000 mg/kg bw (practically nontoxic). Acute dermal toxicity (mammals): LD50 >10000 mg/kg bw. Acute inhalation toxicity (mammals): At 15 mg/cu m, 0.7% was found in the hilar lymph nodes indicating penetration of titanium dioxide particles from alveoli into the lymphatic system and partial clearance by the lymphatic route.

Aquatic toxicity: Acute fish toxicity: LC50 225-500 mg/L. Chronic fish toxicity: LC25 >340 mg/L. Acute *Daphnia* toxicity: LC50 7.6-9.2 mg/L. Chronic *Daphnia* toxicity: LC25 9.4-26.4 mg/L. Acute crustacean toxicity: LC50 >20000 mg/L. Acute algal

toxicity: EC50 35.9 mg/L. Chronic algal toxicity: LC25 1-2 mg/L. Both acutely and chronically hazardous to the aquatic environment.

Terrestrial Toxicity: Acute earthworm toxicity: LC50 >10000 mg/kg. Oral honeybee toxicity: LC50 5.865 mg/L.

In vitro toxicity: No published data.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/26042#section=European-Community-%28EC%29-Number
[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15171/5/1
[3] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.033.327
[4] https://echa.europa.eu/hu/information-on-chemicals/cl-inventory-database/-/discli/details/100661
[5] https://www.sciencedirect.com/science/article/abs/pii/S0308814620307032
[6] https://www.sciencedirect.com/science/article/abs/pii/S0048969716313845
[7] https://joann-whalen.research.mcgill.ca/publications/Environmental%20Toxicology%20and%20Chemistry%202012%20v31%20pp184-193.pdf
[8] https://www.researchgate.net/profile/Chitra_Kc/publication/313771246_Assessment_of_acute_toxicity_LC_50_-96_h_of_aluminium_oxide_silicon_dioxide_and_titanium_dioxide_nanoparticles_on_the_freshwater_fish_Oreochromis_mossambicus_Peters_1852/links/58a57c21a6fdcc0e0765ddba/Assessment-of-acute-toxicity-LC-50-96-h-of-aluminium-oxide-silicon-dioxide-and-titanium-dioxide-nanoparticles-on-the-freshwater-fish-Oreochromis-mossambicus-Peters-1852.pdf
[9] https://www.tandfonline.com/doi/abs/10.1080/17435390902788078
[10] https://www.nature.com/articles/s41598-021-85153-1

32. 1,2-Propanediol (CAS 57-55-6)

General information: Non-biobased plastic additive, with 76.09 molecular weight. Miscible with water, melting point: <-20 °C. Not persistent, readily biodegradable. Low potential for bioaccumulation.

Human Toxicity: CLP hazard classification: not classified. Not carcinogenic, negative for genotoxicity and mutagenicity, and no reproductive/developmental toxicity was observed. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): LD50 22000 mg/kg bw (practically nontoxic). Acute dermal toxicity (mammals): LD50 >2000 mg/kg bw. Acute inhalation toxicity (mammals): LC50 >317 mg/L (practically nontoxic).

Aquatic toxicity: Acute fish toxicity: LC50 40613 mg/L. Acute *Daphnia* toxicity: EC50 18340 mg/L. Chronic *Daphnia* toxicity: NOEC 13020 mg/L. Acute crustacean toxicity: LC50 18800 mg/L. Acute algal toxicity: EC50 19000 mg/L. Not acutely hazardous to the aquatic environment, chronic toxicity data is inconclusive.

Terrestrial Toxicity: No published data.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/16001/1/1

[2] https://pubchem.ncbi.nlm.nih.gov/compound/Propylene-Glycol#section=Toxicological-Information

33. Silica (CAS 7631-86-9)

General information: Non-biobased plastic additive, with 60.84 g/mol molecular weight. Insoluble in water, melting point: 1716-1736 °C. Not persistent.

Human Toxicity: CLP hazard classification: H373; P501; P260; H331; H332; H330. Not classified as carcinogenic, genotoxic, mutagenic or reproductive/developmental toxicant. Not classified as irritating or sensitizing to the skin/eye/respiratory system. Acute oral toxicity (mammals): LD50 >2000 mg/kg. Acute dermal toxicity (mammals): LD50 >2000 mg/kg.

Aquatic toxicity: Acute fish toxicity: LC50 >5000 mg/L. Chronic *Daphnia* toxicity: NOEC >149.2 mg/L. Acute algal toxicity: NOEC 173 mg/L. Neither acutely nor chronically hazardous to the aquatic environment.

Terrestrial Toxicity: No published data.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/24261

[2] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.carlroth.com/medias/SDB-3955-MT-EN.pdf?context=bWFzdGVyfHNlY3VyaXR5RGF0YXNoZWV0c3wyMjgyMDd8YXBwbGljYXRpb24vcGRmfHNlY3VyaXR5RGF0YXNoZWV0cy9oNGQvaGNiLzkwNDcxMzc3Nzk3NDlucGRmfGRjOTVhODYyYTliYzU5ZjdlYjEyZTc5MGE4NWE3YTZlZmZiMjI3MDFhYjZiNGMxNzg5YmFlMWJmMTVjYjViYzY

[3] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15556/6/2/2

[4] chrome extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.euroquarz.com/fileadmin/user_upload/dokumente/sicherheitsdatenblaetter_englisch/MSDS_Quartz_STOT_RE_2_SDS_01-03-2021_GB-IE_English_.pdf

[5] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://echa.europa.eu/documents/10162/bf92a787-c50f-c453-7a9f-ee0446d01a91

34. Titanium chloride TiCl4 (CAS 7550-45-0)

General information: Non-biobased plastic additive, with 189.7 g/mol molecular weight. It is unstable and reactive towards water, and on reaction produces hydrochloric acid and insoluble oxides; melting point: -24.1 °C. No information available on persistency and biodegradability. Low bioaccumulation potential.

Human Toxicity: CLP hazard classification: H314. Not carcinogenic, does not exhibit genotoxic/mutagenic potential, and there is no indication of any reproductive/developmental toxicity. It is toxic if inhaled and is corrosive to the skin and eyes. Acute inhalation toxicity (mammals): LC50 0.46 mg/L (moderately toxic).
Aquatic toxicity: The hydrolysis products of TiCl4 do not exhibit acute or chronic toxicity to aquatic organisms. Neither acutely nor chronically hazardous to the aquatic environment.
Terrestrial Toxicity: No chronic toxic effects to soil macroorganisms exposed to microdisperse matter, while nanoscaled material could exhibit effects. No subacute toxic effects to soil micro-organisms in saturated solution together with undissolved microdisperse matter in excess.
In vitro toxicity: No published data.
References:
[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15171
[2] https://pubchem.ncbi.nlm.nih.gov/compound/Titanium-tetrachloride

35. Polyphosphoric acids, ammonium salts (CAS 68333-79-9)

General information: Non-biobased plastic additive, with 149.09 molecular weight. Soluble in water, melting point: 141-225 °C. No information available on persistency and biodegradation. Potential for bioaccumulation is considered to be minimal.
Human Toxicity: CLP hazard classification: H302; H319. No information available on carcinogenity. Not considered to be genotoxic/mutagenic or being a reproductive/developmental toxicant. It is irritating to the eyes and not irritating or sensitizing to the skin/respiratory system. Acute oral toxicity (mammals): LD50 300-2000 mg/kg bw (slightly toxic). Acute inhalation toxicity (mammals): LC50 >4.85 mg/L.
Aquatic toxicity: No published data.
Terrestrial Toxicity: No published data.
In vitro toxicity: Not genotoxic/mutagenic.
References:
[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/11698/1/1 ,
[2] https://pubchem.ncbi.nlm.nih.gov/compound/Phosphoric-acid_-ammonium-salt-_1_3#section=Toxicity

36. Kaolin (CAS 95077-05-07)

General information: Non-biobased plastic additive, with 258.16 g/mol molecular weight. Insoluble in water, melting point: >1300 °C. Not persistent.
Human Toxicity: CLP hazard classification: H372; H373. Not classified as carcinogenic, genotoxic, mutagenic or being a reproductive/developmental toxicant. Irritating to

the skin, eyes and respiratory system. Acute oral toxicity (mammals): LD50 >5000 mg/kg bw (practically nontoxic). Acute dermal toxicity (mammals): LD50 >5000 mg/kg bw. Acute inhalation toxicity (mammals): EPA OPP 81-3 moderately red lungs (two males, four females) and dark red foci present in one female lung customarily seen with CO2 inhalation, euthanasia procedure; all other tissues and organs appeared normal.

Aquatic toxicity: Acute fish toxicity: LC50 >100 mg/L. Acute *Daphnia* toxicity: EC50 >100 mg/L. Chronic *Daphnia* toxicity: NOEC >1000 mg/L. Acute algal toxicity: EC50 2500 mg/L. Neither acutely nor chronically hazardous to the aquatic environment.

Terrestrial Toxicity: Acute microorganism toxicity: EC50 2800 mg/L.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/56841936#section=Other-Identifiers

[2] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.carlroth.com/medias/SDB-1TCL-AU-EN.pdf?context=bWFzdGVyfHNlY3VyaXR5RGF0YXNoZWV0c3wyMDkxNTR8YXBwbGljYXRpb24vcGRmfHNlY3VyaXR5RGF0YXNoZWV0cy9oYzMvaDkzLzkxMDQyMDU0NDcxOTgucGRmfDBjYTMyNjU1NzI3Y2U1ZGY1MmJiNDQwZDJlYzcwZjgzMmNjMTRmNmRmNzNjMzE4ODg4NWI0NWUzN2U2ZDAxN2U

[3] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.fishersci.dk/store/msds?partNumber=10010220&productDescription=1KG+Kaolin%252C+pure%252C+light%252C+washed+with+acid&countryCode=DK&language=en

[4] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/13356/6/2/2

37. 2,5-Furandione (CAS 108-31-6)

General information: Non-biobased plastic additive, with 98.06 g/mol molecular weight. Reactive towards water, melting point: 53 °C. No information available on persistency and biodegradability.

Human Toxicity: CLP hazard classification: H302; H314; H317; H334. Not classified as carcinogenic, did not cause a positive mutagenic response in any of the bacterial tester strains, either with or without metabolic activation. No information available on reproductive/developmental toxicity. Vapours, fumes and dust are strong irritant to the skin, eyes and respiratory system. Acute oral toxicity (mammals): LD50 400-875 mg/kg (slightly toxic). Acute dermal toxicity (mammals): LD50 2620 mg/kg (slightly toxic). Acute inhalation toxicity (mammals): LC50 >0.199 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 (48h) 138 mg/L. Acute *Daphnia* toxicity: EC50 (24h) 5600 mg/L. Inconclusive data on acute and chronic hazards to the aquatic environment.

Terrestrial Toxicity: No published data.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15798

[2] https://pubchem.ncbi.nlm.nih.gov/compound/Maleic-Anhydride

38. Zinc oxide ZnO (CAS 1314-13-2)

General information: Non-biobased plastic additive, with 81.4 g/mol molecular weight. Insoluble in water, melting point: 1974 °C. No information available on persistency and biodegradability. Not bioaccumulative.

Human toxicity: CLP hazard classification: H400; H410. Not classified as carcinogenic, genotoxic, mutagenic or being a reproductive/developmental toxicant. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): LD50 >2000 mg/kg. Acute dermal toxicity (mammals): LD50 >2000 mg/kg. Acute inhalation toxicity (mammals): LC50 >5.7 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 0.112 mg/L. Acute *Daphnia* toxicity: EC50 0.112 mg/L. Chronic *Daphnia* toxicity: EC50 0.112 mg/L. Acute aquatic plant toxicity: EC50 0.1-0.125 mg/L. Acute algal toxicity: EC50 3.5 mg/L. Chronic algal toxicity: EC50 0.3 mg/L. Very hazardous to the aquatic environment both acutely and chronically.

Terrestrial toxicity: Acute microorganism toxicity: The IC50 values of soluble Zn for endogenous respiration, BOD biodegradation, the first step of nitrification (*e.g.*, ammonia oxidation), and the second step of nitrification (*e.g.*, nitrite oxidation) were 2.2, 1.3, 0.8, and 7.3 mg-Zn/L, respectively.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/56841936#section=Other-Identifiers

[2] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.carlroth.com/medias/SDB-1TCL-AU-EN.pdf?context=bWFzdGVyfHNlY3VyaXR5RGF0YXNoZWV0c3wyMDkxNTR8YXBwbGljYXRpb24vcGRmfHNlY3VyaXR5RGF0YXNoZWV0cy9oYzMvaDkzLzkxMDQyMDU0NDcxOTgucGRmfDBjYTMyNjU1NzI3Y2U1ZGY1MmJiNDQwZDJlYzcwZjgzMmNjMTRmNmRmNzNjMzE4ODg4NWI0NWUzN2U2ZDAxN2U

[3] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.fishersci.dk/store/msds?partNumber=10010220&productDescription=1KG+Kaolin%252C+pure%252C+light%252C+washed+with+acid&countryCode=DK&language=en

[4] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/13356/6/2/2

39. Octanedecanoic acid (CAS 57-11-04)

General information: Non-biobased plastic additive, with 284.5 g/mol molecular weight. Practically insoluble in water, melting point: 64.89-69.3 °C. No information available on persistency and biodegradability.

Human Toxicity: CLP hazard classification: H315; H319; H335; H412. Not classified as carcinogenic, genotoxic, mutagenic or being a reproductive/developmental toxicant. Irritating to the respiratory system, not sensitizing or irritating to the skin/eyes. Acute oral toxicity (mammals): LD50 >6000 mg/kg bw (practically nontoxic). Acute dermal toxicity (mammals): LD50 >2000 mg/kg bw. Acute inhalation toxicity (mammals): LC50 >0.1521 mg/L.

Aquatic toxicity: No acute or chronic effects within water solubility to fish, *Daphnia* and algae. Not expected to be acutely or chronically hazardous to the aquatic environment.

Terrestrial Toxicity: No published data.

In vitro toxicity: Cytotoxicity: the test substance did not induce structural chromosomal aberrations in the absence or presence of an exogenous metabolic activation system. Inflammation: long-chain SFA induce proinflammatory cytokines in human macrophages via pathways involving de novo ceramide synthesis.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15163/7/7/1,
[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15163/1/1,
[3] https://academic.oup.com/endo/article/142/8/3590/2989439?login=true,
[4] https://www.sciencedirect.com/science/article/pii/S0006291X03004492via%3Dihub#BIB11,
[5] https://www.sciencedirect.com/science/article/pii/S0021915008003419?via%3Dihub

40. Hexadecanoic acid (CAS 57-10-03)

General information: Non-biobased plastic additive, with 256.42 molecular weight. Practically insoluble in water, melting point: 62.5 °C. No information available on persistency and biodegradability.

Human Toxicity: CLP hazard classification: H315; H319; H335; H412. Not classified as carcinogenic, genotoxic, mutagenic or being a reproductive/developmental toxicant. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): LD50 >5000 mg/kg bw (practically nontoxic). Acute dermal toxicity (mammals): LD50 >2000 mg/kg bw. Acute inhalation toxicity (mammals): LC50 >0.1521 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 (96h) >1000mg/L. No effects within water solubility in acute and chronic tests with *Daphnia* and algae. Poses no real risk to aquatic organisms neither acutely nor chronically.

Terrestrial Toxicity: No published data.

In vitro toxicity: Cytotoxicity/oxidative stress: causes lipo-toxicity and apoptosis, exhibited a dose-dependent cytotoxic effect associated with ROS production, and did not induce structural chromosomal aberrations in the absence or presence of an exogenous metabolic activation system. Inflammation: saturated fatty acids like

palmitic acid (C16:0) induce the production of IL-18 and IL-1β in an NLRP3 dependent manner.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15218/1/1,
[2] https://pubchem.ncbi.nlm.nih.gov/compound/985#section=Toxicity-Summary,
[3] https://www.mdpi.com/2072-6643/11/12/2974,
[4] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0184282,
[5] https://pubmed.ncbi.nlm.nih.gov/26674288/.,
[6] https://academic.oup.com/endo/article/142/8/3590/2989439?login=true

41. Bentonite, acid-leached (CAS 70131-50-9)

General information: Non-biobased plastic additive, with no defined molecular weight. Insoluble in water, melting point: >450 °C. Inorganic substance, not biodegradable.

Human Toxicity: CLP hazard classification: not classified. Does not induce genotoxicity/mutagenicity. No information available on carcinogenicity and reproductive/developmental toxicity. Not sensitizing and irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): LD50 >5000 mg/kg bw (practically nontoxic). Acute dermal toxicity (mammals): LD50 >2000 mg/kg bw. Acute inhalation toxicity (mammals): LC50 200 mg/L (practically nontoxic).

Aquatic toxicity: Acute *Daphnia* toxicity: LOEC >100 mg/L. Chronic algal toxicity: LOEC >100 mg/L. Inconclusive data on acute and chronic hazards to the aquatic environment.

Terrestrial Toxicity: Acute microorganism toxicity: NOEC (3h) >1000 mg/L.

In vitro toxicity: No published data.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15148/4/9 ;
[2] https://pubchem.ncbi.nlm.nih.gov/compound/Bentonite_-acid-leached.
[3] https://echa.europa.eu/hu/information-on-chemicals/cl-inventory-database/-/discli/notification-details/104729/1182467

42. Phosphorous (CAS 7723-14-0)

General information: Non-biobased plastic additive, with 30.97 g/mol molecular weight. Insoluble in water, melting point: 44.1 °C. Inorganic substance, not biodegradable.

Human Toxicity: CLP hazard classification: H250; H300; H314; H330; H400; H412. Not classified as carcinogenic, no genotoxicity, mutagenicity or reproductive/developmental toxicity was observed. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): LD50 2000 mg/kg bw (slightly toxic). Acute inhalation toxicity (mammals): LC50 >5.75 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 (96h) Hering (*Clupea harengus*) 3.7 µg/L, bluegill (*Lepomis macrochirus Rafinesque*) 45 µg/L, cod (*Gadus morhus*) 2.3 µg/L, atlantic salmon (*Salmo salis*) 2.3 µg/L, Brook trout (*Salvelinus fontinalis*) 2.5 µg/L, Smelt (*Osmerus mordax*) 2.5 µg/L, Killifish (*Fundulus heteroclitus*) > 20 µg/L. Acute *Daphnia* toxicity: NOEC (48h) 0.03 mg/L. Acute algal toxicity: White phosphorus is of limited water solubility (3 mg/L) and the solubilised substance is rapidly oxidised to phosphate. It is well documented that phosphates are critical nutrients required for the growth of algae and other aquatic plants. Very hazardous both acutely and chronically to the aquatic environment.

Terrestrial Toxicity: Acute microorganism toxicity: NOEC (3h) 1000 mg/L.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/Phosphorus.

[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15360/1/2

43. Phenol, 2,6-bis(1,1-dimethylethyl)- (CAS 128-39-2)

General information: Non-biobased plastic additive, with 206.32 g/mol molecular weight. Water solubility: 3.99 g/L, melting point: 37 °C. Not persistent or bioaccumulative.

Human Toxicity: CLP hazard classification: H315; H400; H410. No information available on carcinogenicity, genotoxicity and mutagenicity. No reproductive/developmental toxicity indicated. Causes skin irritation, not irritating or sensitizing to the eyes/respiratory system. Acute oral toxicity (mammals): LD50 >5000 mg/kg bw (practically nontoxic). Acute dermal toxicity (mammals): LD50 >5000 mg/kg bw.

Aquatic toxicity: Acute fish toxicity: LC50 (96h) fathead minnow 1.4 mg/L, rainbow trout (*Oncorhynchus mykiss*) >1.0 mg/L, zebrafish (*danio rerio*) 10 mg/L. Acute *Daphnia* toxicity: EC50 0.45 mg/L. Chronic *Daphnia* toxicity: 0.035 mg/L. Acute algal toxicity: EC50 1.2 mg/L. Chronic algal toxicity: NOEC 0.64 mg/L. Very hazardous both acutely and chronically to the aquatic environment.

Terrestrial Toxicity: Acute earthworm toxicity: LC50 (8 weeks) 208 mg/kg dry weight. Acute microorganism toxicity: NOEC (3h) 12 mg/L.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/2_6-DI-Tert-butylphenol ;

[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/14369/5/4/2

[3] https://hpvchemicals.oecd.org/ui/handler.axd?id=eee5c430-348b-4b29-a7c4-580889959ee2

44. 1,3-Propanediol (CAS 504-63-2)

General information: Non-biobased plastic additive, with 76.09 molecular weight. Miscible with water, melting point: -24.6 °C. Not persistent, readily biodegradable.

Human toxicity: CLP hazard classification: not classified. No information available on carcinogenicity. Not genotoxic, mutagenic or has reproductive/developmental toxicity. Sensitizing to the skin, not irritating or sensitizing to the eyes/respiratory system. Acute oral toxicity (mammals): LD50 4773 mg/kg (practically nontoxic). Acute dermal toxicity (mammals): LD50 >4200 mg/kg. Acute inhalation toxicity (mammals): LC50 >1.8 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 (96h) Fathead minnow >9720 mg/L. Acute *Daphnia* toxicity: EC50 7417 mg/L. Acute algal toxicity: EC50 >10000 mg/L. Not acutely hazardous to the aquatic environment.

Terrestrial toxicity: Microorganism toxicity: NOEC 6000 mg/L.

In vitro toxicity: *In vitro* (Mutagenic effects - bacterial): OECD 471. Negative. *In vitro* (Cytogenic effects–mammalian): EU Method B.10. positive. *In vitro* (Mutagenic effects - mammalian): OECD 476; CHL fibroblasts (V79): negative.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/1_3-Propanediol ;
[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/2099
[3] https://doi.org/10.1080/08958370590964485
[4] https://journals.sagepub.com/doi/pdf/10.1080/109158100225015

45. Decanedioic acid (CAS 111-20-6)

General information: Non-biobased plastic additive, with 202.25 g/mol molecular weight. Slightly soluble in water, melting point: 135 °C. Not persistent or bioaccumulative.

Human toxicity: CLP hazard classification: not classified. No information available on carcinogenicity. Not genotoxic or mutagenic and data is not sufficient for classification as a reproductive/developmental toxicant. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): LD50 >5000 mg/kg bw (practically nontoxic). Acute dermal toxicity: LD50 2000 mg/kg bw (slightly toxic).

Aquatic toxicity: Acute fish toxicity: LC50 zebrafish >100 mg/L. Data is insufficient for hazard classification to the aquatic environment.

Terrestrial toxicity: No published data.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/5192
[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15318

46. Zic chloride ZnCl2 (CAS 7646-85-7)

General information: Non-biobased plastic additive, with 136.3 g/mol molecular weight. Water solubility: 851 g/L, melting point: 287 °C. Not persistent or bioaccumulative.

Human Toxicity: CLP hazard classification: H302; H314; H400; H410. No adequate experimental animal studies are available to evaluate the carcinogenicity of zinc compounds in humans. Not genotoxic or mutagenic, reproductive/developmental toxicity: LOAEL 30 mg/kg/day. Excessive zinc exposure have been implicated with neurogenerative diseases like Alzheimer's or Wilson's disease undefined or with immunosuppressive effects, but the exact mechanisms have not been elucidated. Corrosive to the skin, causes serious eye damage. Acute oral toxicity (mammals): LD50 1100 mg/kg bw (slightly toxic). Acute dermal toxicity (mammals): LD50 >2000 mg/kg bw. Acute inhalation toxicity (mammals): LC50 2 mg/L (slightly toxic).

Aquatic toxicity: Acute fish toxicity: LC50 pH6 0.215 mg/L, pH8 0.435 mg/L (*Cottus bairdii*). Chronic fish toxicity: NOEC (30d) 0.026-1.184 mg/L (*Cyprinus carpio*). Acute *Daphnia* toxicity: EC50 pH6 0.154 mg/L, pH8 0.095 mg/L. Chronic *Daphnia* toxicity: NOEC 0.074 mg/L. Acute algal toxicity: EC50 0.005-0.131 mg/L. Very hazardous both acutely and chronically to the aquatic environment.

Terrestrial toxicity: Acute microorganism toxicity: EC50 5.2 mg/L. Soil microorganisms have been exposed during 7 weeks to different Zn concentration (0, 10, 100, 1000 mg Zn/kg soil, added doses) in different types of soil with a pH ranging from 5.1 to 6.2. The resulting EC10s for nitrification are ranging from 78 to 640 mg Zn/kg dw (total concentration).

In vitro toxicity: Cytotoxicity: in human keratinocytes HaCaT cells non-cytotoxic effects up to 10 µg/mL after 24 h, no significant effect on cell proliferation when exposed to 5 or 1 µg/mL ZnCl2 at 72 h and upregulation of eight genes (EC50 3 h 193.1 µg/mL, 12 h 16.8 µg/mL , 24 h13.5 µg/mL). Exposure of murine photoreceptor cells to high level ZnCl2 can lead to excessive reactive oxygen species over-generation, enhance the cytochrome c release into cytosol, decrease the ATP production, and collapse the mitochondrial membrane potential, disrupt the balance between Bax and Bcl-2, and finally disturb the homeostasis of mitochondria, initiate mitochondria-mediated apoptotic signalling pathway, and then induce cell death. ROS generation/oxidative stress: with the increment of concentrations of ZnCl2 incubated with murine photoreceptor cells, the levels of ZnCl2-induced hydrogen peroxide and hydroxyl radicals were also elevated, and there existed significant differences for the amounts of ZnCl2-induced hydrogen peroxide and hydroxyl radicals compared with those of untreated cells. Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/5192

[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15318

47. Chromium oxide Cr2O3 (CAS 1308-38-9)

General information: Non-biobased plastic additive, with 151.99 g/mol molecular weight. Practically insoluble in water, melting point: 2435 °C. The potential for bioaccumulation of chromium (III) oxide in aquatic and terrestrial environments is low based on its poor solubility in environmental media and the low bioaccumulation factors reported for chromium.

Human Toxicity: CLP hazard classification: H302; H317; H319; H360. A number of published carcinogenicity studies have been performed with chromium (III) oxide. Studies are largely non-standard, use different routes of administration but are consistently negative. Similarly, a number of studies performed using other chromium (III) compounds are consistently negative. May cause genetic defects, and suspected of damaging fertility or the unborn child. Sensitizing to the skin and respiratory system. Acute oral toxicity (mammals): LD50 >5000 mg/kg bw (practically nontoxic). Acute inhalation toxicity (mammals): LC50 >5.41 mg/L.

Aquatic toxicity: Acute and chronic toxicity to fish, *Daphnia* and algae is not expected. Inconclusive data on acute and chronic hazards to the aquatic environment.

Terrestrial Toxicity: Expected to have a low potential for toxicity to soil invertebrates.

In vitro toxicity: Has a high cytotoxic potential. Soluble chromium(III) substances were assessed in a number of *In vitro* genotoxicity assays showing no genotoxic potential, clastogenic or aneugenic potency.

References:

[1] https://echa.europa.eu/es/registration-dossier/-/registered-dossier/15477/7/7/1,
[2] https://pubchem.ncbi.nlm.nih.gov/compound/Chromium_III_-oxide#section=Antidote-and-Emergency-Treatment,
[3] https://echa.europa.eu/es/substance-information/-/substanceinfo/100.013.783

48. Talc $Mg_3H_2(SiO3)_4$ (CAS 14807-96-6)

General information: Non-biobased plastic additive, with 361.25 g/mol molecular weight. Practically insoluble in water, melting point: 900-1000 °C. Inorganic substance, not persistent or bioaccumulative.

Human Toxicity: CLP hazard classification: H400; H413; H410; H411; H412. Not carcinogenic, genotoxic, mutagenic or has reproductive/developmental toxicity. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): LD50 >5000 mg/kg bw (practically nontoxic). Acute dermal toxicity (mammals): LD50 >2000 mg/kg bw. Acute inhalation toxicity (mammals): LC50 2.1 mg/L (slightly toxic).

Aquatic toxicity: Acute *Daphnia* toxicity: LC50 36812 mg/L. Chronic *Daphnia* toxicity: NOEC 1460 mg/L. Acute algal toxicity: EC50 7203 mg/L. Chronic algal toxicity: NOEC

918 mg/L. Not acutely hazardous to the aquatic environment, data on chronic hazards is inconclusive.

Terrestrial Toxicity: No published data.

In vitro toxicity: Not cytotoxic. Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/44134961#section=Substances

[2] https://echa.europa.eu/hu/substance-information/-/substanceinfo/100.035.328

49. 1,3-Dioxolane (CAS 646-06-0)

General information: Non-biobased plastic additive, with 74.08 g/mol molecular weight. Miscible with water, melting point: -90 °C. Not persistent, predicted bioaccumulation is low.

Human toxicity: CLP hazard classification: H225; H318. Considered to be non-carcinogenic, does not exhibit genotoxic/mutagenic potential and does not meet the criteria for reproductive/developmental toxicity. Causes serious eye damage, not sensitizing or irritating to the skin/respiratory system. Acute oral toxicity (mammals): LD50 >2000 mg/kg bw. Acute inhalation toxicity (mammals): LC50 68.4 mg/L (practically nontoxic).

Aquatic toxicity: Acute fish toxicity: LC50 >95.4 mg/L. Chronic fish toxicity: NOEC 546.3 mg/L. Acute *Daphnia* toxicity: EC50 >772 mg/L. Chronic *Daphnia* toxicity (predicted): NOEC 197.4 mg/L. Acute algal toxicity: EC50 877 mg/L. Neither acutely nor chronically hazardous to the aquatic environment.

Terrestrial toxicity: No published data.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://echa.europa.eu/es/registration-dossier/-/registered-dossier/15807/1/1,

[2] https://pubchem.ncbi.nlm.nih.gov/compound/1_3-Dioxolane

50. Tin chloride SnCl2 (CAS 7772-99-8)

General information: Non-biobased plastic additive, with 189.6 g/mol molecular weight. Water solubility: 178 g/L, melting point: 247 °C. Not persistent or bioaccumulative.

Human Toxicity: CLP hazard classification: H290; H302; H332; H314; H317; H318; H335; H373; H415; H315; H341; H361; H400; H410. Not carcinogenic, genotoxic, mutagenic or has reproductive/developmental toxicity. It is immunsupressant. Corrosive to the skin, no information available on eye/respiratory system sensitisation or irritation. Acute oral toxicity (mammals): practically nontoxic. Acute inhalation toxicity (mammals): practically nontoxic.

Aquatic toxicity: Acute fish toxicity: LC50 9 mg/L (*Tapes decussata*), 50 mg/L (*Venerupis aurea*). Chronic fish toxicity: NOEC 4.7 mg/L (zeabrafish). Acute *Daphnia* toxicity: LC50 (48h) 55 mg/L, LC50 (96h) 21 mg/L. Chronic *Daphnia* toxicity: NOEC 0.18 mg/L. Chronic toxicity to sediment dwelling organisms: EC10 5.7 mg/kg dw. Acute algal toxicity: EC50 (2h) 52 mg/L, EC50 (4h) 12 mg/L. Chronic algal toxicity: NOEC 0.053 mg/L. Both acutely and chronically hazardous to the aquatic environment.

Terrestrial Toxicity: Microorganism toxicity: NOEC (20d) 297 mg/kg dw.

In vitro toxicity: Cytotoxicity: IC50 54 mg/L (*Tetrahymena pyriformis*). It has ROS generating effect. Genotoxicity/mutagenicity: positive response in TA102; SnCl2 induced a two-fold increase in mutation in the Mutoxitest strain IC203 (uvrA oxyR). Chromosomal aberration in CHO cells.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/13167/1/1

[2] C.R Silva, M.B.N Oliveira, S.F Melo, F.J.S Dantas, J.C.P de Mattos, R.J.A.C Bezerra, A Caldeira-de-Araujo, A Duatti, M Bernardo-Filho (2002). Biological effects of stannous chloride, a substance that can produce stimulation or depression of the central nervous system. Brain Research Bulletin,59(3):213-216

[3] Pungartnik C, Viau C, Picada J, Caldeira-de-Araújo A, Henriques JA, Brendel M. Genotoxicity of stannous chloride in yeast and bacteria. Mutat Res. 2005 Jun 6;583(2):146-57

[4] F.M. El-Demerdash, M.I. Yousef, Malak A. Zoheir (2005). Stannous chloride induces alterations in enzyme activities, lipid peroxidation and histopathology in male rabbit: Antioxidant role of vitamin C. Food and Chemical Toxicology, 43(12):1743-1752

[5] https://pubchem.ncbi.nlm.nih.gov/compound/24479#section=Names-and-Identifiers

51. Silica gel (CAS 112926-00-8)

General information: Non-biobased plastic additive, with 60.08 g/mol molecular weight. Practically insoluble in water, melting point: 526.9 °C. Not persistent or bioaccumulative.

Human Toxicity: CLP hazard classification: not classified. Not carcinogenic, genotoxic, mutagenic or has reproductive/developmental toxicity. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): LD50 >5000 mg/kg bw (practically nontoxic). Acute dermal toxicity (mammals): LD50 >2000 mg/kg bw. Acute inhalation toxicity (mammals): LC50 < 2.19 mg/L.

Aquatic toxicity: Acute fish toxicity: LC0 10000 mg/L (zebrafish). Chronic fish toxicity: NOEC 86 mg/L. Acute *Daphnia* toxicity: EC50 >10000 mg/L. Chronic Daphnia toxicity: NOEC 68 mg/L. Toxicity to sediment dwelling organisms: NOEC 1000 mg/kg dw. Acute algal toxicity: EC50 >173 mg/L. Neither acutely nor chronically hazardous to the aquatic environment.

Terrestrial Toxicity: Earthworm toxicity: LC50 (28d) 70700 mg/kg dw.

In vitro toxicity: Cytotoxicity: EC50 >2500 mg/L. Inflammation: different forms of silica cause inflammation in rat alveolar macrophages. Genotoxicity/mutagenicity: active in CCRIS mutagenicity study.

References:

[1] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/15556/1/1

[2] Zong ZS, Zhang R, Zhang J, Shao H. [Inhibition of NLRP3 inflammasome activation on the inflammatory response of macrophage induced by silica dust] . Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 2020 Jun 20;38(6):406-409

[3] Wiemann, Martin, Antje Vennemann, Michael Stintz, Rodrigo R. Retamal Marín, Frank Babick, Gottlieb-Georg Lindner, Tobias B. Schuster, Ulrich Brinkmann, and Nils Krueger. 2019. "Effects of Ultrasonic Dispersion Energy on the Preparation of Amorphous SiO2 Nanomaterials for *In vitro* Toxicity Testing" Nanomaterials 9, no. 1: 11

[4] https://pubchem.ncbi.nlm.nih.gov/compound/24261#section

52. Benzenepropanoic acid (CAS 501-52-0)

General information: Non-biobased plastic additive, with 150.17 g/mol molecular weight. Water solubility: 6229 g/L, melting point: 47 °C. Not persistent or bioaccumulative, readily biodegradable in water (100%).

Human Toxicity: CLP hazard classification: H315; H319; H335. No information available on carcinogenicity, genotoxicity, mutagenicity and reproductive/developmental toxicity. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): no adverse effects (LD50 2726 mg/kg bw).

Aquatic toxicity: Acute fish toxicity: LC50 100 mg/L. Acute *Daphnia* toxicity: EC50 16.6-860 mg/L. Acute algal toxicity: EC50 123 mg/L. Not acutely hazardous to the aquatic environment.

Terrestrial Toxicity: Microorganism toxicity: LC50 150.1 mg/L.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/

[2] https://comptox.epa.gov/dashboard/

[3] https://chemview.epa.gov/chemview/#

[4] https://pubchem.ncbi.nlm.nih.gov/

53. Phenol, 2,4-bis(1,1-dimethylethyl)-, 1,1',1''-phosphite (CAS 31570-04-04)

General information: Non-biobased plastic additive, with 646.9 g/mol molecular weight. Insoluble in water, melting point: 185.2 °C. Persistent, no biodegradation observed in water (100%).

Human Toxicity: CLP hazard classification: H312; H315; H319; H411; H412; H413. Not carcinogenic, genotoxic or mutagenic. No information available on reproductive/developmental toxicity. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): no adverse effects

(LD50 6000 mg/kg bw). Acute dermal toxicity (mammals): no adverse effects (LD50 2000 mg/kg bw).

Aquatic toxicity: Acute fish toxicity: LC0 100 mg/L. Acute *Daphnia* toxicity: EC50 510 mg/L. Chronic *Daphnia* toxicity: NOEC 2 mg/L. Toxicity to sediment dwelling organisms: NOEC 1000 mg/kg. Acute algal toxicity: EC50 75.2 mg/L. Not acutely hazardous to the aquatic environment, chronic toxicity data is inconclusive.

Terrestrial Toxicity: Microorganism toxicity: EC10 1000 mg/kg soil dw.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://echa.europa.eu/information-on-chemicals/cl-inventory-database/
[2] https://comptox.epa.gov/dashboard/
[3] https://chemview.epa.gov/chemview/#
[4] https://pubchem.ncbi.nlm.nih.gov/
[5] https://doi.org/10.1016/j.fct.2023.113877

54. 2-Propanol, 1-chloro-, 2,2',2''-phosphate (CAS 13674-84-5)

General information: Non-biobased plastic additive, with 327.6 g/mol molecular weight. Miscible with water, melting point: -51 °C. Not persistent or bioaccumulative.

Human Toxicity: CLP hazard classification: H302. No information available on carcinogenicity, genotoxicity or mutagenicity. Not a reproductive/developmental toxicant. USA EPA proposed guideline for acute delayed neurotoxicity. Not sensitizing or irritating to the skin/eyes/respiratory system. Acute oral toxicity (mammals): LD50 632-4200 mg/kg (slightly toxic). Acute dermal toxicity (mammals): LD50 2000 mg/kg (slightly toxic). Acute inhalation toxicity (mammals): LC50 4.6 mg/L (slightly toxic).

Aquatic toxicity: Acute fish toxicity: LC50 (96h) zebrafish (*Danio rerio*) 56 mg/L, Bluegill Sunfish (*Lepomis macrochirus*) 84 mg/L, Fathead Minnows (*Pimephales promelas*) 51 mg/L, Guppy (*Poecilia reticulata*) 30 mg/L. Acute *Daphnia* toxicity: EC50 135 mg/L. Chronic *Daphnia* toxicity: NOEC 32 mg/L. Acute algal toxicity: EC50 45 mg/L. Chronic algal toxicity: NOEC 6 mg/L. Data is conclusive but not sufficient for classification to being acutely or chronically hazardous to the aquatic environment.

Terrestrial Toxicity: Acute earthworm toxicity: LC50 33 mg/kg dw. Microorganism toxicity: EC50 784 mg/L.

In vitro toxicity: Cytotoxicity: in the neutral red uptake assay TCPP showed a moderate toxicity in V79 cells at concentrations above 1 mM,in the presence of the external metabolizing enzyme system (S9-mix). In the absence of S9-mix no cytotoxic effect could be detected up to concentrations of 10mM. Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/Tris_1-chloro-2-propyl_-phosphate

[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/1355/1/1

55. Polyphosphoric acids, ammonium salts (CAS 68333-79-9)

General information: Non-biobased plastic additive, with no defined molecular weight. Soluble in water, melting point: 141-225 °C. Inorganic substance, not persistent or bioaccumulative.

Human Toxicity: CLP hazard classification: H302; H319. No information available on carcinogenicity. Not genotoxic, mutagenic or has reproductive/developmental toxicity. Causes serious eye irritation, not sensitizing or irritating to the skin/respiratory system. Acute oral toxicity (mammals): LD50 300-2000 mg/kg bw (slightly toxic). Acute inhalation toxicity (mammals): LC50 >4.85 mg/L.

Aquatic toxicity: Acute fish toxicity: LC50 (96h) >100 mg/L (rainbow trout). Acute *Daphnia* toxicity: NOEC 100 mg/L. Acute algal toxicity: NOEC 97.1 mg/L. Not acutely hazardous to the aquatic environment.

Terrestrial Toxicity: No published data.

In vitro toxicity: Not genotoxic/mutagenic.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/Polyphosphoric-acids_-ammonium-salts ;
[2] https://echa.europa.eu/hu/registration-dossier/-/registered-dossier/11698/1/1

56. *cis*,*cis*-muconic acid (CAS 1119-72-8)

General information: Biobased plastic additive, with 142.11 g/mol molecular weight. No information available on water solubility, melting point: 195 °C. Not persistent or bioaccumulative.

Human Toxicity: CLP hazard classification: H302; H315; H319; H335. No information available on carcinogenicity, genotoxicity, mutagenicity or reproductive/developmental toxicity. May cause respiratory irritation, causes skin irritation and serious eye irritation.

Aquatic toxicity: No published data.

Terrestrial Toxicity: No published data.

In vitro toxicity: No published data.

References:

[1] https://pubchem.ncbi.nlm.nih.gov/compound/cis_cis-Muconic-acid ;
[2] https://echa.europa.eu/lt/substance-information/-/substanceinfo/100.157.066 ;
[3] https://echa.europa.eu/lt/information-on-chemicals/cl-inventory-database/-/discli/notification-details/161754/1027311 ;
[4] https://www.sigmaaldrich.com/HU/en/sds/aldrich/15992?userType=anonymous