

ENVIRONMENTAL ATTRIBUTES FOR PLASTIC ADDITIVES

TECHNICAL FIELD

5 The present disclosure relates to systems for producing an plastic additive associated with an plastic additive passport or digital asset, methods for producing an plastic additive associated with an plastic additive passport or digital asset, apparatuses for generating an plastic additive passport or digital asset, computer-implemented methods for generating a chemical passport, computer program elements for generating an plastic additive passport or digital asset, uses of
10 an plastic additive associated with an plastic additive passport or digital asset, uses of an plastic additive passport or digital asset, products produced from the plastic additive and associated with an plastic additive passport or digital asset, a plastic additive, an plastic additive passport or digital asset including one or more decentral identifier(s) and data related to the environmental impact data, apparatuses for producing a product associated with the plastic additive passport or digital asset and methods for producing a product associated with the plastic additive
15 passport or digital asset.

TECHNICAL BACKGROUND

20 In supply chains the environmental impact of each supply chain participants is of great interest. Specifically in the field of plastics, plastic additives are employed for a wide range of applications and are supplied to diverse value chains. In such complex systems transparency between value chain participants is hard to achieve.

25 SUMMARY OF THE INVENTION

In one aspect disclosed is a system for producing a plastic additive associated with an plastic additive passport or a digital asset, the system comprising:

- a chemical production network configured to produce the plastic additive wherein the
30 plastic additive is produced from one or more input material(s) through one or more chemical process(s) of the chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s);
- a production operating apparatus configured to generate the plastic additive passport or
35 digital asset by

providing a decentral identifier associated with the produced plastic additive and one or more environmental attribute(s) of the one or more input material(s) and/or the one or more chemical process(s);

linking the decentral identifier and the environmental attribute(s);

- 5 - providing the produced plastic additive in association with the plastic additive passport or digital asset.

In another aspect disclosed is a system for producing a plastic additive associated with an plastic additive passport or a digital asset, the system comprising:

- 10 - a chemical production network configured to produce the plastic additive, wherein the plastic additive is produced from one or more input material(s) through one or more chemical process(s) of the chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s);
- 15 - a production operating apparatus configured to generate the plastic additive passport or digital asset by providing a decentral identifier associated with the produced plastic additive and linking the decentral identifier and the environmental attribute(s) of the one or more input material(s) and/or the one or more chemical process(s).

- 20 In one aspect disclosed is a system for producing a plastic additive associated with an plastic additive passport or a digital asset, the system comprising:

- a chemical production network configured to produce the plastic additive wherein the plastic additive is produced from one or more input material(s) through one or more chemical process(s) of the chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s);
- 25 - a production operating apparatus configured to generate the plastic additive passport or digital asset by
- providing a decentral identifier associated with the produced plastic additive and
- 30 one or more environmental attribute(s) of the one or more input material(s) and/or the one or more chemical process(s);
- linking the decentral identifier and the environmental attribute(s);
- optionally the chemical production network or the system is configured to provide the produced plastic additive in association with the plastic additive passport or digital asset.

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In another aspect disclosed is a system for producing a plastic additive associated with an plastic additive passport or digital asset, the system comprising:

- a chemical production network configured to produce the plastic additive from one or more input material(s) through chemical process(s), wherein the one or more input material(s) and/or the chemical process(s) are associated with environmental attribute(s);
- a production operating apparatus configured to generate the plastic additive passport or digital asset by providing and/or linking a decentral identifier associated with the plastic additive and one or more environmental attribute(s) associated with the one or more input material(s) and/or the chemical process(s).

In another aspect disclosed is a method for producing a plastic additive associated with an plastic additive passport or digital asset, wherein the method comprises:

- producing the plastic additive from one or more input material(s) through one or more chemical process(s) of a chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s);
- generating the plastic additive passport or digital asset by providing a decentral identifier associated with the produced plastic additive and one or more environmental attribute(s) associated with the one or more input material(s) and/or the one or more chemical process(s);
- linking the decentral identifier and the one or more environmental attribute(s);
- providing the produced plastic additive in association with the plastic additive passport or digital asset.

In another aspect disclosed is a method for producing a plastic additive associated with an plastic additive passport or a digital asset, wherein the method comprises:

- producing the plastic additive from one or more input material(s) through one or more chemical process(s) of a chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s),
- generating the plastic additive passport or digital asset by providing and/or linking a decentral identifier associated with the plastic additive and one or more environmental attribute(s) of the one or more input material(s) and/or the chemical process(s).

In another aspect disclosed is an apparatus for generating a passport or digital asset associated with a plastic additive, wherein the plastic additive is produced from one or more input material(s) through one or more chemical process(s) of a chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s), the apparatus comprising:

- decentral identity provider configured to provide a decentral identifier associated with the produced plastic additive and one or more environmental attribute(s) of the one or more input material(s) and/or the one or more chemical process(s) used to produce the plastic additive;
- 5 - an assignor configured to link the decentral identifier and the environmental attribute(s);
- a passport provider configured to provide the plastic additive passport or digital asset in association with the produced plastic additive e.g. to a decentral network, wherein the environmental attribute(s) associated with the plastic additive is
- 10 made accessible to a user of the plastic additive through the plastic additive passport or digital asset.

In another aspect disclosed is a method, e.g. a computer-implemented method, for generating an plastic additive passport or digital asset associated with an plastic additive, wherein the plastic additive is produced from one or more input material(s) through one or more chemical process(s) of a chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s), the method comprising:

- providing a decentral identifier associated with the produced plastic additive and one or more environmental attribute(s) of the one or more input material(s) and/or the one or more chemical process(s) used to produce the plastic additive;
- 20 - linking the decentral identifier and the environmental attribute(s);
- providing the plastic additive passport or digital asset in association with the produced plastic additive e.g. to a decentral network, wherein the environmental attribute(s) associated with the plastic additive is made accessible to a user of the
- 25 plastic additive through the plastic additive passport or digital asset.

In another aspect disclosed is a computer element, such as a computer readable storage medium, a computer program or a computer program product, comprising instructions, which when executed by a computing node or a computing system, direct the computing node or computing system to carry out the steps of the computer-implemented methods disclosed herein.

In another aspect disclosed is a computer element, such as a computer readable storage medium, a computer program or a computer program product, comprising instructions, which when executed by the apparatuses disclosed herein, direct the apparatuses to carry out steps the apparatuses disclosed herein are configured to execute.

In another aspect disclosed is a plastic additive associated with a plastic additive passport or a digital asset as produced according to the methods disclosed herein. In another aspect disclosed is an plastic additive associated with an plastic additive passport or digital asset as produced according to the systems disclosed herein.

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In another aspect disclosed is a plastic additive associated with a plastic additive passport or digital asset, wherein the plastic additive is produced from one or more input material(s) through one or more chemical process(s) of a chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s), wherein the plastic additive passport or digital asset includes a decentral identifier associated with the produced plastic additive and a link to environmental attribute(s) associated with one or more environmental attribute(s) of one or more input material(s) and/or one or more chemical process(s) used to produce the plastic additive.

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15 In another aspect disclosed is a plastic additive passport or digital asset as generated according to the methods disclosed herein. In another aspect disclosed is an plastic additive passport or digital asset as generated according to the apparatuses disclosed herein.

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In another aspect disclosed is a production system for producing a product from the plastic additive associated with the plastic additive passport or digital asset as provided according to the systems, apparatuses or methods disclosed herein. In another aspect disclosed is a production method for producing a product from the plastic additive associated with the plastic additive passport or digital asset as provided according to the systems, apparatuses or methods disclosed herein.

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In another aspect disclosed is a use of the plastic additive associated with the plastic additive passport or digital asset as disclosed herein for producing a product from the plastic additive associated with the plastic additive passport or digital asset.

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In another aspect disclosed is a use of the plastic additive passport or digital asset as disclosed herein for generating a product passport or digital asset associated with a product produced from the plastic additive associated with the plastic additive passport or digital asset. In another aspect disclosed is a method for using the digital asset generated according to the methods disclosed herein in production of a product produced from the plastic additive associated with

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the plastic additive passport or digital asset.

In another aspect disclosed is a plastic additive associated with a digital asset including a de-central identifier associated with the plastic additive and linked to one or more environmental attribute(s) of the one or more input material(s) and/or the one or more chemical process(s) used to produce the plastic additive.

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In another aspect disclosed is a use of the plastic additive associated with the plastic additive passport or digital asset for producing a product from the plastic additive and associating the plastic additive passport or digital asset with the product produced from the plastic additive. In another aspect disclosed is a use of the plastic additive associated with the plastic additive passport or digital asset for producing a product from the plastic additive and deriving a product passport or digital asset from the plastic additive passport or digital asset. In another aspect disclosed is a method for using the plastic additive associated with the digital asset for producing a product from the plastic additive as disclosed herein and deriving a digital asset associated with the product from the plastic additive passport or plastic additive digital asset.

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Any disclosure and embodiments described herein relate to the methods, the systems, chemical products, plastics additives, plastic additive passports, digital assets and the computer elements lined out above and below. Advantageously, the benefits provided by any of the embodiments and examples equally apply to all other embodiments and examples.

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EMBODIMENTS

In the following, embodiments of the present disclosure will be outlined by ways of embodiments and/or example. It is to be understood that the present disclosure is not limited to said embodiments and/or examples.

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Determining, generating includes initiating or causing to determine, generate. Providing includes "initiating or causing to access, determine, generate, send or receive". "Initiating or causing to perform an action" includes any processing signal that triggers a computing node to perform the respective action.

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The methods, the systems, plastic additives, plastic additive passports, digital assets and the computer elements disclosed herein provide an efficient, secure and robust way for sharing or exchanging environmental impact data across different participant nodes in value chains. In particular, by providing plastic additive specific data via the plastic additive passport or digital asset, environmental impacts can be shared and made transparent from the material to the product produced from such material. The plastic additive passport or digital asset enables se-

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cure data exchange, since data access can be controlled by the plastic additive provider. The exchanges data assets can be specific to the plastic additive as produced and tailored to the needs of the plastic additive user., e.g. the entity providing the plastic additive. The exchanged data assets can be specific to the plastic additive as produced and tailored to the needs of the consumer of the plastic additive. This way an improved tracking and tracing of plastic additives can be achieved by securely providing environmental impact data in diverse and highly complex value chains. The environmental impact of plastics additives can hence be tracked leading to simpler, more efficient and sustainable handling of plastics additives by value chain participants.

Plastic additives associated with the plastic additives passport or digital asset may be selected from antioxidants, UV absorbers, sterically hindered amines, light stabilizers, metal deactivators, phosphites, phosphonates, hydroxylamines and amine N-oxides, nitrones, thiosynergists, acid scavengers, nucleating agents, fillers and reinforcing agents, benzofuranones and indolinones, flame retardants, rheology modifiers and combinations thereof.

Preferred plastic additives are selected from phenolic antioxidants, UV absorbers, sterically hindered amines light stabilizer, phosphites, flame retardants and combinations thereof.

Plastic additives may for example be selected from the following list:

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1. Antioxidants

1.1. Alkylated monophenols, for example 2,6-di-tert-butyl-4-methylphenol, 2-tert-butyl-4,6-di-methylphenol, 2,6-di-tert-butyl-4-ethylphenol, 2,6-di-tert-butyl-4-n-butylphenol, 2,6-di-tert-butyl-4-isobutylphenol, 2,6-dicyclopentyl-4-methylphenol, 2-(α -methylcyclohexyl)-4,6-dimethylphenol, 2,6-dioctadecyl-4-methylphenol, 2,4,6-tricyclohexylphenol, 2,6-di-tert-butyl-4-methoxymethyl-phenol, nonylphenols which are linear or branched in the side chains, for example 2,6-di-nonyl-4-methylphenol, 2,4-dimethyl-6-(1'-methylundec-1'-yl)phenol, 2,4-dimethyl-6-(1'-methylheptadec-1'-yl)phenol, 2,4-dimethyl-6-(1'-methyltridec-1'-yl)phenol, 2,4-dimethyl-6-(1'-methyl-1'-tetradecyl-methyl)-phenol and mixtures thereof.

1.2. Alkylthiomethylphenols, for example 2,4-dioctylthiomethyl-6-tert-butylphenol, 2,4-dioctylthio-methyl-6-methylphenol, 2,4-dioctylthiomethyl-6-ethylphenol, 2,6-di-dodecyl-thiomethyl-4-nonylphenol.

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1.3. Hydroquinones and alkylated hydroquinones, for example 2,6-di-tert-butyl-4-methoxy-phenol, 2,5-di-tert-butylhydroquinone, 2,5-di-tert-amylhydroquinone, 2,6-diphenyl-4-octadecyl-oxy-phenol, 2,6-di-tert-butylhydroquinone, 2,5-di-tert-butyl-4-hydroxyanisole, 3,5-di-tert-butyl-4-hydroxyanisole, 3,5-di-tert-butyl-4-hydroxyphenyl stearate, bis(3,5-di-tert-butyl-4-hydroxyphenyl) adipate.

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1.4. Tocopherols, for example α -tocopherol, β -tocopherol, γ -tocopherol, δ -tocopherol and mixtures thereof (vitamin E), vitamin E acetate.

5 Especially preferred is the addition of 2,5,7,8-tetramethyl-2-[4,8,12-trimethyltridecyl]-chroman-6-ol], which is a commercially available vitamin E (e.g. Irganox E 201TM).

1.5. Hydroxylated thiodiphenyl ethers, for example 2,2'-thiobis(6-tert-butyl-4-methylphenol), 2,2'-thiobis(4-octylphenol), 4,4'-thiobis(6-tert-butyl-3-methylphenol), 4,4'-thiobis(6-tert-butyl-2-methylphenol), 4,4'-thiobis(3,6-di-sec-amylphenol), 4,4'-bis(2,6-dimethyl-4-
10 hydroxyphenyl)disulfide.

1.6. Alkylidenebisphenols, for example 2,2'-methylenebis(6-tert-butyl-4-methylphenol), 2,2'-methylenebis(6-tert-butyl-4-ethylphenol), 2,2'-methylenebis[4-methyl-6-(α -methylcyclohexyl)phenol], 2,2'-methylenebis(4-methyl-6-cyclohexylphenol), 2,2'-methylenebis(6-nonyl-4-methylphenol), 2,2'-methylenebis(4,6-di-tert-butylphenol), 2,2'-ethylenebis(4,6-di-tert-butylphenol), 2,2'-ethylenebis(6-tert-butyl-4-isobutylphenol), 2,2'-methylenebis[6-(α -methylbenzyl)-4-nonylphenol], 2,2'-methylenebis[6-(α,α -dimethylbenzyl)-4-nonylphenol], 4,4'-methylenebis(2,6-di-tert-butylphenol), 4,4'-methylenebis(6-tert-butyl-2-methylphenol), 1,1-bis(5-tert-butyl-4-hydroxy-2-methylphenyl)butane, 2,6-bis(3-tert-butyl-5-methyl-2-hydroxybenzyl)-4-methylphenol, 1,1,3-tris(5-tert-butyl-4-hydroxy-2-methylphenyl)butane, 1,1-bis(5-tert-butyl-4-hydroxy-2-methylphenyl)-3-n-dodecylmercaptobutane, ethylene glycol bis[3,3-bis(3'-tert-butyl-4'-hydroxyphenyl)-butyrate], bis(3-tert-butyl-4-hydroxy-5-methylphenyl)dicyclopentadiene, bis[2-(3'-tert-butyl-2'-hydroxy-5'-methylbenzyl)-6-tert-butyl-4-methylphenyl]terephthalate, 1,1-bis-(3,5-dimethyl-2-hydroxyphenyl)butane, 2,2-bis(3,5-di-tert-butyl-4-hydroxyphenyl)propane, 2,2-bis-(5-tert-butyl-4-hydroxy-2-methylphenyl)-4-n-dodecylmercaptobutane, 1,1,5,5-tetra(5-tert-butyl-4-hydroxy-2-methylphenyl)pentane.

1.7. O-, N- and S-benzyl compounds, for example 3,5,3',5'-tetra-tert-butyl-4,4'-di-hydroxydibenzyl ether, octadecyl-4-hydroxy-3,5-dimethylbenzylmercaptoacetate, tridecyl-4-hydroxy-3,5-di-tert-butylbenzylmercaptoacetate, tris(3,5-di-tert-butyl-4-hydroxybenzyl)-amine, bis(4-tert-butyl-3-hydroxy-2,6-dimethylbenzyl)dithioterephthalate, bis(3,5-di-tert-butyl-4-hydroxybenzyl)sulfide, isooctyl-3,5-di-tert-butyl-4-hydroxybenzylmercaptoacetate.

35 1.8. Hydroxybenzylated malonates, for example dioctadecyl-2,2-bis(3,5-di-tert-butyl-2-hydroxybenzyl)malonate, di-octadecyl-2-(3-tert-butyl-4-hydroxy-5-methylbenzyl)malonate, di-dodecylmercaptoethyl-2,2-bis(3,5-di-tert-butyl-4-hydroxybenzyl)malonate, bis[4-(1,1,3,3-tetramethylbutyl)phenyl]-2,2-bis(3,5-di-tert-butyl-4-hydroxybenzyl)malonate.

40 1.9. Aromatic hydroxybenzyl compounds, for example 1,3,5-tris(3,5-di-tert-butyl-4-hydroxybenzyl)-2,4,6-trimethylbenzene, 1,4-bis(3,5-di-tert-butyl-4-hydroxybenzyl)-2,3,5,6-tetramethylbenzene, 2,4,6-tris(3,5-di-tert-butyl-4-hydroxybenzyl)phenol.

- 1.10. Triazine compounds, for example 2,4-bis(octylmercapto)-6-(3,5-di-tert-butyl-4-hydroxyanilino)-1,3,5-triazine, 2-octylmercapto-4,6-bis(3,5-di-tert-butyl-4-hydroxyanilino)-1,3,5-triazine, 2-octylmercapto-4,6-bis(3,5-di-tert-butyl-4-hydroxyphenoxy)-1,3,5-triazine, 2,4,6-tris(3,5-di-tert-butyl-4-hydroxyphenoxy)-1,2,3-triazine, 1,3,5-tris(3,5-di-tert-butyl-4-hydroxybenzyl)isocyanurate, 1,3,5-tris(4-tert-butyl-3-hydroxy-2,6-dimethylbenzyl)isocyanurate, 2,4,6-tris(3,5-di-tert-butyl-4-hydroxyphenylethyl)-1,3,5-triazine, 1,3,5-tris(3,5-di-tert-butyl-4-hydroxyphenylpropionyl)-hexahydro-1,3,5-triazine, 1,3,5-tris(3,5-dicyclohexyl-4-hydroxybenzyl)isocyanurate.
- 1.11. Benzylphosphonates, for example dimethyl-2,5-di-tert-butyl-4-hydroxybenzylphosphonate, diethyl-3,5-di-tert-butyl-4-hydroxybenzylphosphonate, dioctadecyl-3,5-di-tert-butyl-4-hydroxybenzylphosphonate, dioctadecyl-5-tert-butyl-4-hydroxy-3-methylbenzylphosphonate, the calcium salt of the monoethyl ester of 3,5-di-tert-butyl-4-hydroxybenzylphosphonic acid, (3,5-ditert-butyl-4-hydroxy-phenyl)methylphosphonic acid.
- 1.12. Acylaminophenols, for example 4-hydroxylauranilide, 4-hydroxystearanilide, octyl N-(3,5-di-tert-butyl-4-hydroxyphenyl)carbamate.
- 1.13. Esters of β -(3,5-di-tert-butyl-4-hydroxyphenyl)propionic acid with mono- or polyhydric alcohols, for example with methanol, ethanol, n-octanol, i-octanol, a mixture of linear and branched C₇-C₉-alkanol, octadecanol, a mixture of linear and branched C₁₃-C₁₅-alkanol, 1,6-hexanediol, 1,9-nonanediol, ethylene glycol, 1,2-propanediol, neopentyl glycol, thiodiethylene glycol, diethylene glycol, triethylene glycol, tetraethylene glycol, pentaerythritol, tris-(hydroxyethyl)isocyanurate, N,N'-bis-(hydroxy-ethyl)oxamide, 3-thiaundecanol, 3-thiapentadecanol, trimethylhexanediol, trimethylolpropane, 4-hydroxymethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2]octane.
- Preferred are esters of β -(3,5-di-tert-butyl-4-hydroxyphenyl)propionic acid, especially with octadecanol, such as the addition of Octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl)-propionate, which is commercially available as e.g. Irganox 1076TM.
- 1.14. Esters of β -(5-tert-butyl-4-hydroxy-3-methylphenyl)propionic acid with mono- or polyhydric alcohols, for example with methanol, ethanol, n-octanol, i-octanol, octadecanol, 1,6-hexanediol, 1,9-nonanediol, ethylene glycol, 1,2-propanediol, neopentyl glycol, thiodiethylene glycol, diethylene glycol, triethylene glycol, pentaerythritol, tris-(hydroxyethyl)isocyanurate, N,N'-bis(hydroxyethyl)oxamide, 3-thiaundecanol, 3-thiapentadecanol, trimethylhexanediol, trimethylolpropane, 4-hydroxymethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2]octane; 3,9-bis[2-{3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propionyloxy}-1,1-dimethylethyl]-2,4,8,10-tetraoxaspiro[5.5]undecane.
- 1.15. Esters of β -(3,5-dicyclohexyl-4-hydroxyphenyl)propionic acid with mono- or polyhydric alcohols, for example with methanol, ethanol, octanol, octadecanol, 1,6-hexanediol, 1,9-nonanediol, ethylene glycol, 1,2-propanediol, neopentyl glycol, thiodiethylene glycol, diethylene glycol, triethylene glycol, pentaerythritol, tris(hydroxyethyl)isocyanurate, N,N'-

bis(hydroxyethyl)oxamide, 3-thiaundecanol, 3-thiapentadecanol, trimethylhexanediol, trimethylolpropane, 4-hydroxymethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2]octane.

- 1.16. Esters of 3,5-di-tert-butyl-4-hydroxyphenyl acetic acid with mono- or polyhydric alcohols, for example with methanol, ethanol, octanol, octadecanol, 1,6-hexanediol, 1,9-nonanediol, ethylene glycol, 1,2-propanediol, neopentyl glycol, thiodiethylene glycol, diethylene glycol, triethylene glycol, pentaerythritol, tris(hydroxyethyl)isocyanurate, N,N'-bis(hydroxyethyl)oxamide, 3-thiaundecanol, 3-thiapentadecanol, trimethylhexanediol, trimethylolpropane, 4-hydroxymethyl-1-phospha-2,6,7-trioxabicyclo[2.2.2]octane.

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- 1.17. Amides of β -(3,5-di-tert-butyl-4-hydroxyphenyl)propionic acid, for example N,N'-bis(3,5-di-tert-butyl-4-hydroxyphenylpropionyl)hexamethylenediamide, N,N'-bis(3,5-di-tert-butyl-4-hydroxyphenylpropionyl)trimethylenediamide, N,N'-bis(3,5-di-tert-butyl-4-hydroxyphenylpropionyl)hydrazide, N,N'-bis[2-(3-[3,5-di-tert-butyl-4-hydroxyphenyl]-propionyloxy)ethyl]oxamide (Naugard XL-1 (RTM), supplied by SI Group).

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1.18. Ascorbic acid (vitamin C)

- 1.19. Aminic antioxidants, for example N,N'-di-isopropyl-p-phenylenediamine, N,N'-di-sec-butyl-p-phenylenediamine, N,N'-bis(1,4-dimethylpentyl)-p-phenylenediamine, N,N'-bis(1-ethyl-3-methylpentyl)-p-phenylenediamine, N,N'-bis(1-methylheptyl)-p-phenylenediamine, N,N'-dicyclohexyl-p-phenylenediamine, N,N'-diphenyl-p-phenylenediamine, N,N'-bis(2-naphthyl)-p-phenylenediamine, N-isopropyl-N'-phenyl-p-phenylenediamine, N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine, N-(1-methylheptyl)-N'-phenyl-p-phenylenediamine, N-cyclohexyl-N'-phenyl-p-phenylenediamine, 4-(p-toluenesulfamoyl)diphenylamine, N,N'-dimethyl-N,N'-di-sec-butyl-p-phenylenediamine, diphenylamine, N-allyldiphenylamine, 4-isopropoxydiphenylamine, N-phenyl-1-naphthylamine, N-(4-tert-octylphenyl)-1-naphthylamine, N-phenyl-2-naphthylamine, octylated diphenylamine, for example p,p'-di-tert-octyldiphenylamine, 4-n-butylaminophenol, 4-butyrylamino-phenol, 4-nonanoylamino-phenol, 4-dodecanoylamino-phenol, 4-octadecanoylamino-phenol, bis(4-methoxyphenyl)amine, 2,6-di-tert-butyl-4-dimethylaminomethylphenol, 2,4'-diaminodiphenylmethane, 4,4'-diaminodiphenylmethane, N,N,N',N'-tetramethyl-4,4'-diaminodiphenylmethane, 1,2-bis[(2-methylphenyl)amino]ethane, 1,2-bis(phenylamino)propane, (o-tolyl)biguanide, bis[4-(1',3'-dimethylbutyl)phenyl]amine, tert-octylated N-phenyl-1-naphthylamine, a mixture of mono- and dialkylated tert-butyl/tert-octyldiphenylamines, a mixture of mono- and dialkylated nonyldiphenylamines, a mixture of mono- and dialkylated dodecyldiphenylamines, a mixture of mono- and dialkylated isopropyl/isohexyldiphenylamines, a mixture of mono- and dialkylated tert-butyldiphenylamines, 2,3-dihydro-3,3-dimethyl-4H-1,4-benzothiazine, phenothiazine, a mixture of mono- and dialkylated tert-butyl/tert-octylphenothiazines or a mixture of mono- and dialkylated tert-octylphenothiazines, N-allylphenothiazine, N,N,N',N'-tetraphenyl-1,4-diaminobut-2-ene, N-[(1,1,3,3-tetramethylbutyl)phenyl]-1-naphthalenamine] (commercially available as Irganox L06™), 4,4'-bis(phenylisopropyl)diphenylamine (commercially available as Naugard 445), Bis(4-(1,1,3,3-tetramethylbutyl)phenyl)amine (commercially available as Irganox 5057)

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Alternatively, or in addition, a commercially available mixture of additives may be used as well, of which especially preferred is Irganox 5057 TM, which is obtained by the reaction of diphenylamine with diisobutylene, and which comprises

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(A)₅₀₅₇ diphenylamine;

(B)₅₀₅₇ 4-tert-butyl diphenylamine;

(C)₅₀₅₇ compounds of the group

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i) 4-tert-octyl diphenylamine,

ii) 4,4'-di-tert-butyl diphenylamine,

iii) 2,4,4'-tris-tert-butyl diphenylamine,

(D)₅₀₅₇ compounds of the group

i) 4-tert-butyl-4'-tert-octyl diphenylamine,

ii) o,o', m,m', or p,p'-di-tert-octyl diphenylamine,

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iii) 2,4-di-tert-butyl-4'-tert-octyl diphenylamine,

(E)₅₀₅₇ compounds of the group

i) 4,4'-di-tert-octyl diphenylamine,

ii) 2,4-di-tert-octyl-4'-tert-butyl diphenylamine, and

wherein not more than 5 % by weight of component (A)₅₀₅₇, 8 to 15 % by weight of component (B)₅₀₅₇, 24 to 32 % by weight of component (C)₅₀₅₇, 23 to 34 % by weight of component (D)₅₀₅₇ and 21 to 34 % by weight of component (E)₅₀₅₇ are present. It is commercially available.

2. UV absorbers and light stabilizers

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2.1. 2-(2'-Hydroxyphenyl)benzotriazoles, for example 2-(2'-hydroxy-5'-methylphenyl)benzotriazole, 2-(3',5'-di-tert-butyl-2'-hydroxyphenyl)benzotriazole, 2-(5'-tert-butyl-2'-hydroxyphenyl)benzotriazole, 2-(2'-hydroxy-5'-(1,1,3,3-tetramethylbutyl)phenyl)benzotriazole, 2-(3',5'-di-tert-butyl-2'-hydroxyphenyl)-5-chlorobenzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-methylphenyl)-5-chlorobenzotriazole, 2-(3'-sec-butyl-5'-tert-butyl-2'-hydroxyphenyl)benzotriazole, 2-(2'-hydroxy-4'-octyloxyphenyl)benzotriazole, 2-(3',5'-di-tert-amyl-2'-hydroxyphenyl)benzotriazole, 2-(3',5'-bis(α,α-dimethylbenzyl)-2'-hydroxyphenyl)benzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-(2-octyloxycarbonyl)ethyl)phenyl)-5-chlorobenzotriazole, 2-(3'-tert-butyl-5'-[2-(2-ethylhexyloxy)carbonyl]ethyl)-2'-hydroxyphenyl)-5-chlorobenzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-(2-methoxycarbonyl)ethyl)phenyl)-5-chlorobenzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-(2-octyloxycarbonyl)ethyl)phenyl)benzotriazole, 2-(3'-tert-butyl-5'-[2-(2-ethylhexyloxy)carbonyl]ethyl)-2'-hydroxyphenyl)benzotriazole, 2-(3'-dodecyl-2'-hydroxy-5'-methylphenyl)benzotriazole, 2-(3'-tert-butyl-2'-hydroxy-5'-(2-isooctyloxy-carbonyl)ethyl)phenyl)benzotriazole, 2,2'-methylenebis[4-(1,1,3,3-tetramethylbutyl)-6-benzotriazole-2-ylphenol]; the transesterification product of 2-[3'-tert-butyl-5'-(2-methoxycarbonyl)ethyl)-2'-hydroxyphenyl]-2H-benzotriazole with polyethylene glycol 300; [R'-CH₂-CH₂-CO-O-CH₂-CH₂]₂, where R' = 3'-tert-butyl-4'-hydroxy-5'-2H-benzotriazole-2-ylphenyl, 2-[2'-hydroxy-3'-(α,α-dimethylbenzyl)-5'-(1,1,3,3-tetra-

methylbutyl)phenyl]benzotriazole; 2-[2'-hydroxy-3'-(1,1,3,3-tetramethylbutyl)-5'-(α,α -dimethylbenzyl)phenyl]benzotriazole.

2.2. 2-Hydroxybenzophenones, for example the 4-hydroxy, 4-methoxy, 4-octyloxy, 4-decyl-
5 oxy, 4-dodecyloxy, 4-benzyloxy, 4,2',4'-trihydroxy and 2'-hydroxy-4,4'-dimethoxy derivatives.

2.3. Esters of substituted and unsubstituted benzoic acids, for example 4-tert-butylphenyl
salicylate, phenyl salicylate, octylphenyl salicylate, dibenzoyl resorcinol, bis(4-tert-
butylbenzoyl)resorcinol, benzoyl resorcinol, 2,4-di-tert-butylphenyl 3,5-di-tert-butyl-4-
10 hydroxybenzoate, hexadecyl 3,5-di-tert-butyl-4-hydroxybenzoate, octadecyl 3,5-di-tert-
butyl-4-hydroxybenzoate, 2-methyl-4,6-di-tert-butylphenyl 3,5-di-tert-butyl-4-
hydroxybenzoate.

2.4. Acrylates, for example ethyl α -cyano- β,β -diphenylacrylate, isooctyl α -cyano- β,β -di-
15 phenylacrylate, methyl α -carbomethoxycinnamate, methyl α -cyano- β -methyl-p-methoxy-
cinnamate, butyl α -cyano- β -methyl-p-methoxycinnamate, methyl α -carbomethoxy-p-
methoxycinnamate, N-(β -carbomethoxy- β -cyanovinyl)-2-methylindoline and neopentyl tetra-
20 ra(α -cyano- β,β -diphenylacrylate), or sterically hindered acrylates such as disclosed in EP-
A-3587425, like for instance (2E,2'E)-2,4,8,10-tetraoxaspiro[5.5]undecane-3,9-diylbis(2-
methylpropane-2,1-diyl) bis(2-cyano-3-(3,4-dimethoxyphenyl)acrylate) [CAS Reg. No.
2233585-18-5], or a similar derivative, wherein the one of the two OCH₃ groups (methoxy) of
each of the (2-cyano-3-(3,4-dimethoxyphenyl)acrylate)moiety is respectively substituted
with a OC₆H₁₃ group, resulting in a bis(2-cyano-3-(3-methoxy-4-hexyloxyphenyl)acrylate)
derivative.

2.5. Nickel compounds, for example nickel complexes of 2,2'-thiobis[4-(1,1,3,3-tetramethyl-
butyl)phenol], such as the 1:1 or 1:2 complex, with or without additional ligands such as n-
butylamine, triethanolamine or N-cyclohexyldiethanolamine, nickel dibutyldithiocarbamate,
nickel salts of the monoalkyl esters, e.g. the methyl or ethyl ester, of 4-hydroxy-3,5-di-tert-
30 butylbenzylphosphonic acid, nickel complexes of ketoximes, e.g. of 2-hydroxy-4-methyl-
phenylundecylketoxime, nickel complexes of 1-phenyl-4-lauroyl-5-hydroxypyrazole, with or
without additional ligands.

2.6. Sterically hindered amines, for example bis(2,2,6,6-tetramethyl-4-piperidyl)sebacate,
35 bis(2,2,6,6-tetramethyl-4-piperidyl)succinate, bis(1,2,2,6,6-pentamethyl-4-
piperidyl)sebacate, bis(1,2,2,6,6-pentamethyl-4-piperidyl) n-butyl-3,5-di-tert-butyl-4-
hydroxybenzylmalonate, the condensate of 1-(2-hydroxyethyl)-2,2,6,6-tetramethyl-4-
hydroxypiperidine and succinic acid, linear or cyclic condensates of N,N'-bis(2,2,6,6-
tetramethyl-4-piperidyl)hexamethylenediamine and 4-tert-octylamino-2,6-dichloro-1,3,5-
40 triazine, tris(2,2,6,6-tetramethyl-4-piperidyl)nitritotriacetate, tetrakis(2,2,6,6-tetramethyl-4-
piperidyl)-1,2,3,4-butanetetracarboxylate, 1,1'-(1,2-ethanediyl)-bis(3,3,5,5-tetra-
methylpiperazinone), 4-benzoyl-2,2,6,6-tetramethylpiperidine, 4-stearyloxy-2,2,6,6-
tetramethylpiperidine, bis(1,2,2,6,6-pentamethylpiperidyl)-2-n-butyl-2-(2-hydroxy-3,5-di-
tert-butylbenzyl)malonate, 3-n-octyl-7,7,9,9-tetramethyl-1,3,8-triazaspiro[4.5]decane-2,4-

dione, bis(1-octyloxy-2,2,6,6-tetramethylpiperid-4-yl)sebacate, bis(1-octyloxy-2,2,6,6-tetramethylpiperid-4-yl)succinate, bis-[2,2,6,6-tetramethyl-1-(undecyloxy)-piperidin-4-yl] carbonate, linear or cyclic condensates of N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)-hexamethylenediamine and 4-morpholino-2,6-dichloro-1,3,5-triazine, the condensate of 2-chloro-4,6-bis(4-n-butylamino-2,2,6,6-tetramethylpiperidyl)-1,3,5-triazine and 1,2-bis(3-aminopropylamino)ethane, the condensate of 2-chloro-4,6-di-(4-n-butylamino-1,2,2,6,6-pentamethylpiperidyl)-1,3,5-triazine and 1,2-bis(3-aminopropyl-amino)ethane, 8-acetyl-3-dodecyl-7,7,9,9-tetramethyl-1,3,8-triazaspiro[4.5]decane-2,4-dione, 3-dodecyl-1-(2,2,6,6-tetramethyl-4-piperidyl)pyrrolidine-2,5-dione, 3-dodecyl-1-(1,2,2,6,6-pentamethyl-4-piperidyl)pyrrolidine-2,5-dione, a mixture of 4-hexadecyloxy- and 4-stearyloxy-2,2,6,6-tetramethylpiperidine, a condensate of N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine and 4-cyclohexylamino-2,6-dichloro-1,3,5-triazine, a condensate of 1,2-bis(3-aminopropylamino)ethane and 2,4,6-trichloro-1,3,5-triazine as well as 4-butylamino-2,2,6,6-tetramethylpiperidine (CAS Reg. No. [136504-96-6]); a condensate of 1,6-hexanediamine and 2,4,6-trichloro-1,3,5-triazine as well as N,N-dibutylamine and 4-butylamino-2,2,6,6-tetramethylpiperidine (CAS Reg. No. [192268 64-7]); reaction products of N6,N6'-hexane-1,6-diylbis[N2,N4-dibutyl-N2,N4,N6-tris(2,2,6,6-tetramethylpiperidin-4-yl)-1,3,5-triazine-2,4,6-triamine], butanal and hydrogen peroxide; N-(2,2,6,6-tetramethyl-4-piperidyl)-n-dodecylsuccinimide, N-(1,2,2,6,6-pentamethyl-4-piperidyl)-n-dodecylsuccinimide, 2-undecyl-7,7,9,9-tetramethyl-1-oxa-3,8-diaza-4-oxo-spiro[4,5]decane, a reaction product of 7,7,9,9-tetramethyl-2-cycloundecyl-1-oxa-3,8-diaza-4-oxospiro[4,5]decane and epichlorohydrin, 1,1-bis(1,2,2,6,6-pentamethyl-4-piperidyl)oxycarbonyl)-2-(4-methoxyphenyl)-ethene, N,N'-bis-formyl-N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine, a diester of 4-methoxymethylenemalonic acid with 1,2,2,6,6-pentamethyl-4-hydroxy-piperidine, poly[methylpropyl-3-oxy-4-(2,2,6,6-tetramethyl-4-piperidyl)]siloxane, a reaction product of maleic acid anhydride- α -olefin copolymer with 2,2,6,6-tetramethyl-4-aminopiperidine or 1,2,2,6,6-pentamethyl-4-amino-piperidine, a mixture of oligomeric compounds which are the formal condensation products of N,N'-bis-(2,2,6,6-tetramethyl-1-propoxy-piperidin-4-yl)-hexane-1,6-diamine and 2,4-dichloro-6-{n-butyl-(2,2,6,6-tetramethyl-1-propoxy-piperidin-4-yl)-amino}-[1,3,5]triazine end-capped with 2-chloro-4,6-bis-(di-n-butylamino)-[1,3,5]triazine, a mixture of oligomeric compounds which are the formal condensation products of N,N'-bis-(2,2,6,6-tetramethyl-piperidin-4-yl)-hexane-1,6-diamine and 2,4-dichloro-6-{n-butyl-(2,2,6,6-tetramethyl-piperidin-4-yl)-amino}-[1,3,5]triazine end-capped with 2-chloro-4,6-bis-(di-n-butylamino)-[1,3,5]triazine, (N2,N4-dibutyl-N2,N4-bis(1,2,2,6,6-pentamethyl-4-piperidinyl)-6-(1-pyrrolidinyl)-[1,3,5]-triazine-2,4-diamine, 2,4-bis[N-(1-cyclohexyloxy-2,2,6,6-tetramethylpiperidine-4-yl)-N-butylamino]-6-(2-hydroxyethyl)amino-1,3,5-triazine, 1-(2-hydroxy-2-methylpropoxy)-4-octadecanoyloxy-2,2,6,6-tetramethylpiperidine, 5-(2-ethylhexanoyl)oxymethyl-3,3,5-trimethyl-2-morpholinone, Sanduvor (Clariant; CAS Reg. No. [106917-31-1]), 5-(2-ethylhexanoyl)-oxymethyl-3,3,5-trimethyl-2-morpholinone, the reaction product of 2,4-bis-[(1-cyclo-hexyloxy-2,2,6,6-piperidine-4-yl)butylamino]-6-chloro-s-triazine with N,N'-bis-(3-amino-propyl)ethylenediamine, 1,3,5-tris(N-cyclohexyl-N-(2,2,6,6-tetramethyl-piperazine-3-one-4-yl)amino)-s-triazine, 1,3,5-tris(N-cyclohexyl-N-(1,2,2,6,6-pentamethylpiperazine-3-one-4-yl)-amino)-s-triazine.

2.7. Oxamides, for example 4,4'-dioctyloxyoxanilide, 2,2'-diethoxyoxanilide, 2,2'-dioctyloxy-5,5'-di-tert-butoxanilide, 2,2'-didodecyloxy-5,5'-di-tert-butoxanilide, 2-ethoxy-2'-ethyloxanilide, N,N'-bis(3-dimethylaminopropyl)oxamide, 2-ethoxy-5-tert-butyl-2'-ethoxanilide and its mixture with 2-ethoxy-2'-ethyl-5,4'-di-tert-butoxanilide, mixtures of o- and p-methoxy-disubstituted oxanilides and mixtures of o- and p-ethoxy-disubstituted oxanilides.

2.8. 2-(2-Hydroxyphenyl)-1,3,5-triazines, for example 2,4,6-tris(2-hydroxy-4-octyloxyphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-octyloxyphenyl)-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2-(2,4-dihydroxyphenyl)-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2,4-bis(2-hydroxy-4-propyloxyphenyl)-6-(2,4-dimethylphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-octyloxyphenyl)-4,6-bis(4-methylphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-dodecyloxyphenyl)-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-tridecyloxyphenyl)-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2-[2-hydroxy-4-(2-hydroxy-3-butyloxypropoxy)phenyl]-4,6-bis(2,4-dimethyl)-1,3,5-triazine, 2-[2-hydroxy-4-(2-hydroxy-3-octyloxypropyloxy)phenyl]-4,6-bis(2,4-dimethyl)-1,3,5-triazine, 2-[4-(dodecyloxy/tridecyloxy-2-hydroxypropoxy)-2-hydroxyphenyl]-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2-[2-hydroxy-4-(2-hydroxy-3-dodecyloxypropoxy)phenyl]-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine, 2-(2-hydroxy-4-hexyloxy)phenyl-4,6-diphenyl-1,3,5-triazine, 2-(2-hydroxy-4-methoxyphenyl)-4,6-diphenyl-1,3,5-triazine, 2,4,6-tris[2-hydroxy-4-(3-butoxy-2-hydroxypropoxy)phenyl]-1,3,5-triazine, 2-(2-hydroxyphenyl)-4-(4-methoxyphenyl)-6-phenyl-1,3,5-triazine, 2-{2-hydroxy-4-[3-(2-ethylhexyl-1-oxy)-2-hydroxypropyloxy]phenyl}-4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine.

3. Metal deactivators, for example N,N'-diphenyloxamide, N-salicylal-N'-salicyloyl hydrazine, N,N'-bis(salicyloyl)hydrazine, N,N'-bis(3,5-di-tert-butyl-4-hydroxyphenyl-propionyl)hydrazine, 3-salicyloylamino-1,2,4-triazole, bis(benzylidene)oxalyl dihydrazide, oxanilide, isophthaloyl dihydrazide, sebacoil bisphenylhydrazide, N,N'-diacetyl adipoyl dihydrazide, N,N'-bis(salicyloyl)oxalyl dihydrazide, N,N'-bis(salicyloyl)thiopropionyl dihydrazide.

4. Phosphites and phosphonates such as Tris alkyl (C12-C15) phosphite, Triisodecyl phosphite, Triisotridecyl phosphite, Dioleil Hydrogen phosphite, Triisooctyl Phosphite, Heptakis (dipropyleneglycol) Triphosphite, Trilauryl Trithio Phosphite, Tris (Dipropyleneglycol) Phosphite, Dimethyl hydrogen phosphite, Dibutyl hydrogen phosphite, Dilauryl hydrogen phosphite, Tri-C12-C14-phosphite or Bis(2-ethylhexyl) hydrogen phosphite. Other phosphites and phosphonates, which are for instance liquid ones such as Di-n-octyl hydrogen phosphite or Di-iso-octyl hydrogen phosphite, or for example triphenyl phosphite, tris(nonylphenyl) phosphite, Phenyl diisodecyl phosphite, Diphenyl isodecyl phosphite, [Triphenyl phosphite, polymer with 1,4-cyclohexanedimethanol and polypropylene glycol, C10-16 alkyl esters (CAS Reg. No. 1821217-71-3)].

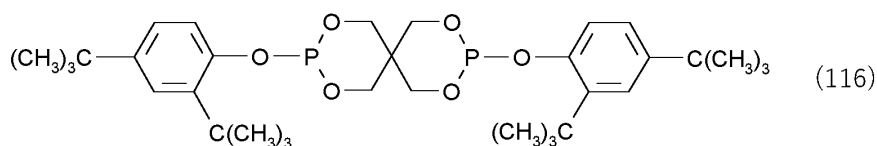
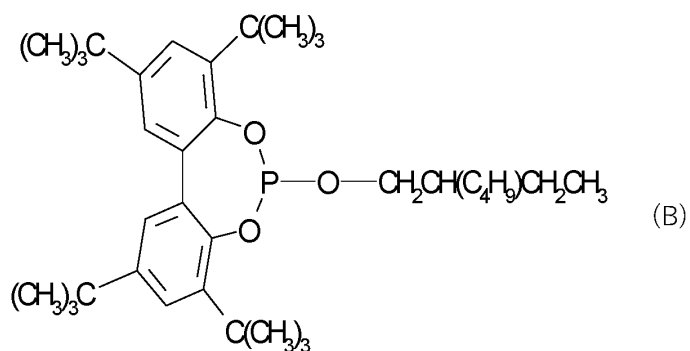
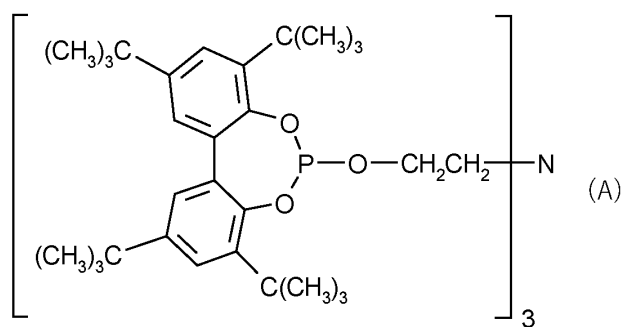
Further optional phosphites or phosphonates additives are for instance Alkyl (C12-C15) bisphenol A phosphite, Alkyl (C10) bisphenol A phosphite, Poly (dipropyleneglycol) phenyl phosphite, Tris (tridecyl) phosphite, Diphenyl phosphite, Dodecyl nonylphenol phosphite blend, Phenyl Neopentylene Glycol Phosphite, Poly 4,4' Isopropylidenediphenol - C10 Alcohol Phosphite, Poly 4,4' Isopropylidenediphenol - C12-15 Alcohol Phosphite, diphenylalkyl

phosphites, phenyldialkyl phosphites, C₁₂-C₁₈ alkyl bis[4-(1-methyl-1-phenyl-ethyl)phenyl] phosphite, C₁₂-C₁₈ alkenyl bis[4-(1-methyl-1-phenyl-ethyl)phenyl] phosphite, bis[4-(1-methyl-1-phenyl-ethyl)phenyl] [(E)-octadec-9-enyl] phosphite, decyl bis[4-(1-methyl-1-phenyl-ethyl)phenyl] phosphite, didecyl [4-(1-methyl-1-phenyl-ethyl)phenyl] phosphite, [4-(1-methyl-1-phenyl-ethyl)phenyl] bis[(E)-octadec-9-enyl] phosphite, triauryl phosphite, trioctadecyl phosphite, distearyl pentaerythritol diphosphite, tris(2,4-di-tert-butylphenyl) phosphite, diisodecyl pentaerythritol diphosphite, bis(2,4-di-tert-butylphenyl) pentaerythritol diphosphite, bis(2,4-di-cumylphenyl) pentaerythritol diphosphite, bis(2,6-di-tert-butyl-4-methylphenyl) pentaerythritol diphosphite, diisodecyloxy pentaerythritol diphosphite, bis(2,4-di-tert-butyl-6-methylphenyl) pentaerythritol diphosphite, bis(2,4,6-tris(tert-butylphenyl)-pentaerythritol diphosphite, [2-tert-butyl-4-[1-[5-tert-butyl-4-di(tridecoxy)phosphanyloxy-2-methyl-phenyl]butyl]-5-methyl-phenyl] ditridecyl phosphite, tristearyl sorbitol triphosphite, a mixture of at least two different tris(mono-C₁-C₈-alkyl)phenyl phosphites such as for example mentioned in US 7468410 B2 as products of examples 1 and 2, a mixture of phosphites comprising at least two different tris(arylphenyl) phosphites such as for example mentioned in US 8008383 B2 as mixtures 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25 and 26, a mixture of at least four different phosphites comprising tris[4-(1,1-dimethylpropyl)phenyl] phosphite, [2,4-bis(1,1-dimethylpropyl)phenyl] bis[4-(1,1-dimethylpropyl)phenyl] phosphite, bis[2,4-bis(1,1-dimethylpropyl)phenyl] [4-(1,1-dimethylpropyl)phenyl] phosphite and tris[2,4-bis(1,1-dimethylpropyl)phenyl] phosphite, a mixture of phosphites comprising at least two different tris(butylphenyl) phosphites such as for example mentioned in US 8008383 B2 as mixtures 34, 35, 36, 37, 38, 39 and 40, an oxyalkylene-bridged bis-(di-C₆-aryl) diphosphite or an oligomeric phosphite obtainable by condensation under removal of hydrogen chloride of (i) a trichlorophosphane, with (ii) a dihydroxyalkane interrupted by one or more oxygen atoms and with (iii) a mono-hydroxy-C₆-arene such as for example mentioned in US 8304477 B2 as products of examples 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 and 17, a polymeric phosphite obtainable by transesterification under removal of phenol of (i) triphenyl phosphite with (ii) a dihydroxyalkane optionally interrupted by one or more oxygen atoms and/or a bis(hydroxyalkyl)(alkyl)amine and with (iii) a mono-hydroxyalkane optionally interrupted by one or more oxygen atoms such as for example mentioned in US 8563637 B2 as products of examples 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11, tetrakis(2,4-di-tert-butylphenyl) 4,4'-biphenylene diphosphonite, 6-isooctyloxy-2,4,8,10-tetra-tert-butyl-12H-dibenz[d,g]-1,3,2-dioxaphosphocine, bis(2,4-di-tert-butyl-6-methylphenyl)methylbis(2,4-di-tert-butyl-6-methylphenyl)methyl phosphite, bis(2,4-di-tert-butyl-6-methylphenyl)ethyl phosphite, 6-fluoro-2,4,8,10-tetra-tert-butyl-12-methyl-dibenz[d,g]-1,3,2-dioxaphosphocine, 1,3,7,9-tetra-tert-butyl-11-octoxy-5H-benzo[d][1,3,2]benzodioxaphosphocine, 2,2',2''-nitriolo[triethyltris(3,3',5,5'-tetra-tert-butyl-1,1'-biphenyl-2,2'-diyl)phosphite], phosphorous acid, triphenyl ester, polymer with α -hydro- ω -hydroxypoly[oxy(methyl-1,2-ethanediyl)], C10-16-alkyl esters (CAS Reg. No. [1227937-46-3]), 2-ethylhexyl(3,3',5,5'-tetra-tert-butyl-1,1'-biphenyl-2,2'-diyl)phosphite, 5-butyl-5-ethyl-2-(2,4,6-tri-tert-butylphenoxy)-1,3,2-dioxaphosphirane, phosphorous acid, mixed 2,4-bis(1,1-dimethylpropyl)phenyl and 4-(1,1-dimethylpropyl)phenyl triesters (CAS Reg. No. [939402-02-5]).

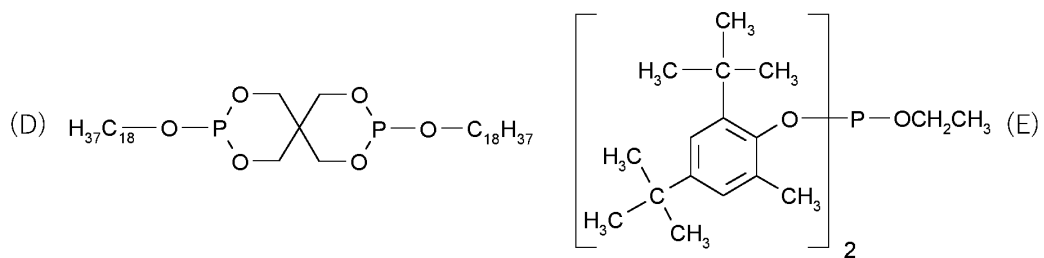
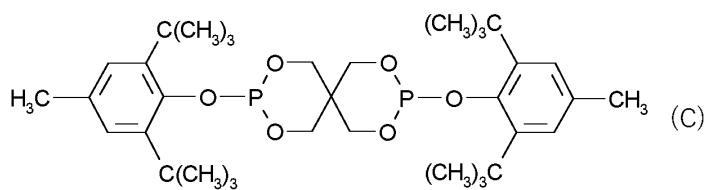
The following phosphites are especially preferred:

Tris(2,4-di-tert-butylphenyl) phosphite (Irgafos®168, Ciba Specialty Chemicals Inc.), tris(nonylphenyl) phosphite,

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5. Hydroxylamines and amine N-oxides, for example N,N-dibenzylhydroxylamine, N,N-diethylhydroxylamine, N,N-dioctylhydroxylamine, N,N-dilaurylhydroxylamine, N,N-ditetradecylhydroxylamine, N,N-dihexadecylhydroxylamine, N,N-dioctadecylhydroxylamine, N-hexadecyl-N-octadecylhydroxylamine, N-heptadecyl-N-octadecylhydroxylamine, N,N-dialkylhydroxylamine derived from hydrogenated tallow amine, N,N-bis-(hydrogenated rape-oil alkyl)-N-methyl-amine N-oxide or trialkylamine N-oxide.
6. Nitrones, for example N-benzyl- α -phenylnitrone, N-ethyl- α -methylnitrone, N-octyl- α -heptylnitrone, N-lauryl- α -undecylnitrone, N-tetradecyl- α -tridecyl-nitrone, N-hexadecyl- α -pentadecylnitrone, N-octadecyl- α -heptadecylnitrone, N-hexadecyl- α -heptadecylnitrone, N-octadecyl- α -pentadecylnitrone, N-heptadecyl- α -heptadecylnitrone, N-octadecyl- α -hexadecylnitrone, nitrone derived from N,N-dialkylhydroxylamine derived from hydrogenated tallow amine.
7. Thiosynergists, for example dilauryl thiodipropionate, dimistryl thiodipropionate, distearyl thiodipropionate and pentaerythritol tetrakis-[3-(n-lauryl)-propionic acid ester].
8. Peroxide scavengers, for example esters of α -thiodipropionic acid, for example the lauryl, stearyl, myristyl or tridecyl esters, mercaptobenzimidazole or the zinc salt of 2-mercaptobenzimidazole, zinc dibutyldithiocarbamate, dioctadecyl disulfide, pentaerythritol tetrakis(β -dodecylmercapto)propionate.
9. Acid scavengers, for example melamine, polyvinylpyrrolidone, dicyandiamide, triallyl cyanurate, urea derivatives, hydrazine derivatives, hydrotalcites, alkali metal salts and alkaline earth metal salts of higher fatty acids, for example calcium stearate, zinc stearate, magnesium behenate, magnesium stearate, sodium ricinoleate and potassium palmitate, antimony pyrocatecholate and zinc pyrocatecholate.
10. Polyamide stabilizers, for example copper salts in combination with iodides and/or phosphorus compounds and salts of divalent manganese.
11. Basic co-stabilizers, for example melamine, polyvinylpyrrolidone, dicyandiamide, triallyl cyanurate, urea derivatives, hydrazine derivatives, amines, polyamides, polyurethanes, alkali metal salts and alkaline earth metal salts of higher fatty acids, for example calcium stearate, zinc stearate, magnesium behenate, magnesium stearate, sodium ricinoleate and potassium palmitate, antimony pyrocatecholate or zinc pyrocatecholate.
12. Nucleating agents, for example inorganic substances, such as talcum, metal oxides, such as titanium dioxide or magnesium oxide, phosphates, carbonates or sulfates of, preferably, alkaline earth metals; organic compounds, such as mono- or polycarboxylic acids and the salts thereof, e.g. 4-tert-butylbenzoic acid, adipic acid, diphenylacetic acid, sodium succinate or sodium benzoate; polymeric compounds, such as ionic copolymers (ionomers). Especially preferred are 1,3:2,4-bis(3',4'-dimethylbenzylidene)sorbitol, 1,3:2,4-di(paramethyldibenzylidene)sorbitol, and 1,3:2,4-di(benzylidene)sorbitol.

13. Fillers and reinforcing agents, for example calcium carbonate, silicates, glass fibres, glass beads, asbestos, talc, kaolin, mica, barium sulfate, metal oxides and hydroxides, carbon black, graphite, wood flour and flours or fibers of other natural products, synthetic fibers.

14. Benzofuranones and indolinones, for example those disclosed in US-A-4,325,863; US-A-4,338,244; US-A-5,175,312; US-A-5,216,052; US-A-5,252,643; DE-A-4316611; DE-A-4316622; DE-A-4316876; EP-A-0589839 or EP-A-0591102, or 5,7-di-tert-butyl-3-(4-hydroxyphenyl)-3H-benzofuran-2-one, 5,7-di-tert-butyl-3-[4-(2-hydroxyethoxy)phenyl]-3H-benzofuran-2-one, 5,7-di-tert-butyl-3-[4-[2-[2-[2-(2-hydroxyethoxy)ethoxy]ethoxy]ethoxy]phenyl]-3H-benzofuran-2-one, 3-[4-(2-acetoxyethoxy)phenyl]-5,7-di-tert-butylbenzofuran-2-one, 5,7-di-tert-butyl-3-[4-(2-stearoyloxyethoxy)phenyl]benzofuran-2-one, 3,3'-bis[5,7-di-tert-butyl-3-(4-[2-hydroxyethoxy]phenyl)benzofuran-2-one], 5,7-di-tert-butyl-3-(4-ethoxyphenyl)benzofuran-2-one, 3-(4-acetoxy-3,5-dimethylphenyl)-5,7-di-tert-butylbenzofuran-2-one, 3-(3,5-dimethyl-4-pivaloyloxyphenyl)-5,7-di-tert-butylbenzofuran-2-one, 3-(3,4-dimethylphenyl)-5,7-di-tert-butylbenzofuran-2-one, 3-(2,3-dimethylphenyl)-5,7-di-tert-butylbenzofuran-2-one, 3-(2-acetoxy-4-(1,1,3,3-tetramethyl-butyl)-phenyl)-5-(1,1,3,3-tetramethyl-butyl)-benzofuran-2-one, [6-[6-[6-[2-[4-(5,7-di-tert-butyl-2-oxo-3H-benzofuran-3-yl)phenoxy]ethoxy]-6-oxo-hexoxy]-6-oxo-hexoxy]-6-oxo-hexyl] 6-hydroxyhexanoate, [4-tert-butyl-2-(5-tert-butyl-2-oxo-3H-benzofuran-3-yl)phenyl] benzoate, [4-tert-butyl-2-(5-tert-butyl-2-oxo-3H-benzofuran-3-yl)phenyl] 3,5-di-tert-butyl-4-hydroxybenzoate and [4-tert-butyl-2-(5-tert-butyl-2-oxo-3H-benzofuran-3-yl)phenyl] 3-(3,5-di-tert-butyl-4-hydroxy-phenyl)propanoate.

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15. Flame retardants

15.1. Phosphorus containing flame retardants including reactive phosphorous containing flame retardants, for example tetraphenyl resorcinol diphosphite (Fyrolflex RDP, RTM, Akzo Nobel), tetrakis(hydroxymethyl)phosphonium sulphide, triphenyl phosphate, diethyl-N,N-bis(2-hydroxyethyl)-aminomethyl phosphonate, hydroxyalkyl esters of phosphorus acids, alkylphosphate oligomers, ammonium polyphosphate (APP), resorcinol diphosphate oligomer (RDP), phosphazene flame retardants or ethylenediamine diphosphate (EDAP).

15.2. Nitrogen containing flame retardants, for example melamine-based flame retardants, isocyanurates, polyisocyanurate, esters of isocyanuric acid, like tris-(2-hydroxyethyl)isocyanurate, tris(hydroxymethyl)isocyanurate, tris(3-hydroxy-*n*-propyl)isocyanurate, triglycidyl isocyanurate, melamine cyanurate, melamine borate, melamine phosphate, melamine pyrophosphate, melamine polyphosphate, melamine ammonium polyphosphate, melamine ammonium pyrophosphate, dimelamine phosphate, dimelamine pyrophosphate, benzoguanamine, allantoin, glycoluril, urea cyanurate, a condensation product of melamine from the series melem, melam, melon and/or a higher condensed compound or a reaction product of melamine with phosphoric acid or a mixture thereof.

- 15.3. Organohalogen flame retardants, for example polybrominated diphenyl oxide, decabromodiphenyl oxide (DBDPO), tris[3-bromo-2,2-bis(bromomethyl)propyl] phosphate (PB 370, (RTM, FMC Corp.)), tris(2,3-dibromopropyl)phosphate, chloroalkyl phosphate esters such as tris(chloropropyl)phosphate, tris(2,3-dichloropropyl)phosphate, tris(1,3-dichloro-2-propyl)phosphate (Fyrol FR 2 (RTM ICL)), oligomeric chloroalkyl phosphate, chlorendic acid, tetrachlorophthalic acid, tetrabromophthalic acid, poly- β -chloroethyl triphosphonate mixture, tetrabromobisphenol A-bis(2,3-dibromopropyl ether) (PE68), brominated epoxy resin, brominated aryl esters, ethylene-bis(tetrabromophthalimide) (Saytex BT-93 (RTM, Albemarle)), bis(hexachlorocyclopentadieno) cyclooctane (Declorane Plus (RTM, Oxychem)), chlorinated paraffins, octabromodiphenyl ether, hexachlorocyclopentadiene derivatives, 1,2-bis(tribromophenoxy)ethane (FF680), tetrabromobisphenol A (Saytex RB100 (RTM, Albemarle)), ethylene bis-(dibromonorborenedicarboximide) (Saytex BN-451 (RTM, Albemarle)), bis-(hexachlorocyclopentadieno)cyclooctane, PTFE, tris (2,3-dibromopropyl) isocyanurate or ethylene-bis-tetrabromophthalimide.
- 15 Some of the halogenated flame retardants mentioned above are routinely combined with an inorganic oxide synergist. Some of the halogenated flame retardants mentioned above can be used in combination with triaryl phosphates (such as the propylated, butylated triphenyl phosphates) and the like and / or with oligomeric aryl phosphates (such as resorcinol bis(diphenyl phosphate), bisphenol A bis(diphenyl phosphate), neopentylglycol bis(diphenyl phosphate)) and the like.

- 15.4. Inorganic flame retardants, for example aluminium trihydroxide (ATH), boehmite (AlOOH), magnesium dihydroxide (MDH), zinc borates, CaCO_3 , organically modified layered silicates, organically modified layered double hydroxides, and mixtures thereof. In regard to the synergistic combination with halogenated flame retardants, the most common inorganic oxide synergists are zinc oxides, antimony oxides like Sb_2O_3 or Sb_2O_5 or boron compounds.

- The chemical production network may include one or more one or more chemical and/or mechanical process(es). The chemical production network may produce one or more output material(s) through chemical and/or mechanical processing. The chemical production network may include multiple types of production processes for producing one or more output material(s) from one or more input material(s). The chemical production network may produce one or more output material(s) from input material(s) provided to the chemical production network. The chemical production network may include a complex production network producing multiple chemical products via multiple production process(es). The chemical production network may include connected, interconnected and/or non-connected production process(es). The chemical production network may include a composite or Verbund network.

- The chemical production network may include identity preserving or segregated production process(es). Identity preserving or segregated in this context may refer to environmental attribute(s) of input material(s) being preserved or segregated in the production process(es). Exam-

ples are non-fossil, e.g. renewable or recycled, input materials used to produce the one or more plastic additive(s) without fossil content. Further examples are fossil input material(s) used to produce the one or more plastic additive(s) with fossil content. Chemical production networks may include non-identity preserving or non-segregated production process(es). Non-identity
5 preserving or non-segregated in this context may refer to non-fossil input material(s) being mixed with fossil input material(s) to produce the plastic additive(s). For example, fossil and renewable input materials may be mixed to produce the plastic additive(s) with fossil and renewable content.

10 The chemical production network may include one or more production process(es) with multiple production steps. The production steps included in the chemical network may be defined by the physical system boundary of the chemical production network. The system boundary may be defined by location and/or control over production processes or steps. The system boundary may be defined by a site of the chemical production network. The system boundary may be de-
15 fined by production process(es) or step(s) controlled by one entity or multiple entities jointly. The system boundary may be defined by the value chain with staggered production process(es) or step(s) to the chemical end product, which may be controlled by multiple entities jointly or separately. The chemical production network may include a waste collection, a sorting step, a recycling step such as pyrolysis, a cracking step such as steam cracking, a separation step to sepa-
20 rate intermediates of one process step and further processing steps to convert such intermediates to output material(s), in particular plastic additive(s) leaving the system boundary of the chemical production network. The input material(s) may enter the physical system boundary of the chemical production network. The entry point(s) of the chemical production network may be marked by the entry of input material(s) to the chemical production network or the system
25 boundary of the chemical network. The output material(s), in particular plastic additive(s) may leave the physical system boundary of the chemical production network. The exit point(s) of the chemical production network may be marked by the exit of output material(s), in particular plastic additive(s) from the chemical production network or the system boundary of the chemical network.

30 The chemical production network may include one or more production chain(s) for the production of plastic additives. The production chain(s) for the production of plastic additives may be interconnected. The production chain(s) for the production of plastic additives may be interconnected with production chain(s) for the production of other output material(s). The production
35 chain(s) for the production of plastic additives may include production chain(s) for the production of intermediates used to produce plastic additives. The production chain(s) for the produc-

tion of plastic additives may use input material(s) provided by chemical network(s) for the production of intermediates usable to produce plastic additives.

One or more input material(s) may be provided to the chemical production network for producing one or more output material(s), in particular plastic additive(s). The output material(s), in particular plastic additive(s) may be produced from one or more input material(s) through one or more chemical process(es) of the chemical production network. The input material may comprise any input material entering the chemical production network at any entry point. The input material may include input material(s) such as a natural, organic or inorganic, and/or output material(s), in particular plastic additive(s). The input material may be a pre-cursor product, an intermediate material, a feedstock or a raw material used to produce one or more output material(s), in particular plastic additive(s). The input material may be fed to the chemical production network to produce one or more output material(s), in particular plastic additive(s). The input material may be fed to chemical production network including one or more production process(es) with multiple process steps. The input material may be fed to the chemical production network at the start of the production process or at any intermediate stage of the production process. The input materials entering the chemical production network may be used to produce one or more output material(s), in particular plastic additive(s).

The input material may be associated with an input material identifier. The input material identifier may comprise any identifier uniquely associated with the input material. The input material identifier may be associated with the physical entity of the input material. The input material identifier may be associated with a single batch of input material. The input material identifier may be associated with a group of input materials. The identifier may be associated with multiple physical entities of the input material. The input material identifier may be associated with continuous or semi-continuous stream of input material. The input material identifier may be associated with a stream of the input material e.g. over a certain time period or from a certain supplier. The input material identifier may be linked or connected to one or more environmental attribute(s).

Environmental attribute may refer to a property related to the environmental impact. Such property may be the property of input material(s), chemical process(es), chemical production network(s) and/or plastic additive(s). The environmental attribute may indicate an environmental performance of input material(s), chemical process(es), chemical production network(s) and/or plastic additive(s). The environmental attribute may be derived from properties of input material(s), chemical process(es), chemical production network(s) and/or plastic additive(s). The environmental attribute may be associated with the environmental impact of input material(s), chem-

- ical process(es), chemical production network(s) and/or plastic additive(s) at any stage of the lifecycle of the plastic additive(s). The stages may include providing raw material, providing feedstock, producing chemical products, such as intermediate products or end products, producing discrete products by using the chemical products, using chemical products or discrete products, treating end-of-life products, recycling end-of-life products, disposing end-of-life products, reusing components from end-of-life products or any subset of stages. The environmental attribute may be specified or may be derived from any activity of one or more entities participating at any stage of the lifecycle of one or more material(s) or product(s).
- 10 The environmental attribute may include one or more characteristic(s) that are attributable to environmental impact of input material(s), chemical process(es), chemical production network(s) and/or plastic additive(s). The environmental attribute may include environmental, technical, recyclability or circularity characteristics(s) associated with the environmental impact of input material(s), chemical process(es), chemical production network(s) and/or plastic additive(s).
- 15 The environmental attribute may include one or more characteristic(s) that are attributable to the environmental impact of input material(s), chemical process(es), chemical production network(s) and/or plastic additive(s). The environmental attribute may include environmental, technical, recyclability or circularity characteristics(s) associated with the environmental impact of input material(s), chemical process(es), chemical production network(s) and/or plastic additive(s). The one or more environmental attribute(s) may be attributable to the environmental impact of the plastic additive. The one or more environmental attribute(s) may relate to environmental, technical, recyclability, circularity and/or complementary risk characteristic(s) of the plastic additive.
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- 25 Environmental characteristic(s) may specify or quantify ecological criteria associated with environmental impact. Environmental characteristic(s) may be or may be derived from measurements taken during the lifecycle. Environmental characteristics may be determined at any stage of the lifecycle and may characterize the environmental impact for such stage or up to such stage. Environmental characteristic(s) may for example include carbon footprint, greenhouse gas emissions, resource usage, air emissions, ozone depletion potential, water pollution, noise pollution, energy consumption, waste reduction, or eutrophication potential. Environmental characteristic(s) may for example include product characteristics related to the production of the product like bio based, vegetable based, animal based, halogen-free, fluorine-free, vegan, halal, kosher, palm oil-free, natural, tox-free, volatile organic compounds-free or any combinations thereof.
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Technical characteristic(s) may specify or quantify performance at least indirectly associated with the environmental impact. Technical characteristic(s) may be or may be derived from measurements taken during the lifecycle. Technical characteristics may be determined at any stage of the lifecycle and may characterize the performance for such stage or up to such stage.

- 5 Technical characteristic(s) may for example include chemical composition data, raw material composition such as bio-based or recycled input material content specifying e.g. x% non fossil and y% fossil content, bill of materials, product specification data such as product purity, product form (as indication to their impact on dust formation/release), safety data, product extractability, migration data, toxicological data or ecotoxicological data, product component data, safety
10 data, application property data, application instructions, quality data or any combinations thereof.

- Circularity characteristic(s) may specify or quantify the life cycle characteristics associated with circular uses. Circularity characteristic(s) may be or may be derived from measurements taken
15 during the lifecycle. Circularity characteristic(s) may be or may be derived from circular data recorded in one or more prior lifecycle(s) including reuse. Circularity characteristic(s) may be determined at any stage of the lifecycle and may characterize the reuse or recycling performance for such stage or up to such stage. Circularity characteristic(s) may for example include recycling data, reuse rate, recycling rate, recycling loops, reuse performance, reused quality or
20 any combinations thereof.

- Recyclability characteristic(s) may specify or quantify life cycle characteristics associated with recycling uses. Recyclability characteristic(s) may include the composition of the material including specifically tailored constituents making the material suitable for recycling. Recyclability
25 characteristic(s) may be or may be derived from measurements taken during the lifecycle. Recyclability characteristic(s) may be or may be derived from recycling data recorded in one or more prior lifecycle(s). Recyclability characteristics may be determined at any stage of the lifecycle and may characterize the recycling performance for such stage or up to such stage. Recyclability characteristic(s) may for example include recycling data, number of reuses, recycle
30 clate composition, recycle quality, waste stream composition, waste stream quality or any combinations thereof.

- In one embodiment the plastic additives passport or digital asset of the plastic additive may include mass balanced environmental attributes related to the input material. Mass balanced environmental attributes may include environmental attributes of the input material(s) used to produce the plastic additive, which are tracked and by mass attributable to the plastic additive. The
35 environmental impact of input material(s) may be determined based on input material(s) used in

the chemical process(s) to produce the plastic additive. For example, bio-based, renewable and/or recycled content of input material(s) used to produce the plastic additive may be tracked. Further for example, castor oil or palm oil content of input material(s) used to produce the plastic additive may be tracked. Further for example, properties related to the environmental impact of the input material include RSPO palm oil, palm oil free or castor oil may be tracked. Further for example, properties of the chemical process(es) used to produce the plastic additive may be tracked. Examples of tracked process properties related to the environmental impact include water consumption, CO₂ emissions and/or Greenhouse Gas (GHG) emissions, amount of waste generation, mixed material generation, design for recycling, energy consumption, processing properties such as less waste or less loss of properties. The properties may be tracked based on a certificate from a certifying agency. The properties may be tracked based on inherent physical properties derived from measurements.

In one embodiment the produced plastic additive is connected to the decentral identifier physically identifying the produced plastic additive. The production operating apparatus may be configured to provide the decentral identifier associated with a physical entity of the produced plastic additive. The production operating apparatus may be configured to link the decentral identifier to a physical identifier of the produced plastic additive. The production operating apparatus may be configured to assign the decentral identifier to the physical identifier connected to the produced plastic additive. The production operating apparatus may be configured to assign the decentral identifier to the physical identifier physically connected to the produced plastic additive.

In one embodiment the decentral identifier relates to data associated with at least one product produced from the plastic additive, wherein the one or more environmental attribute(s) associated with the at least one product is derived from one or more environmental attribute(s) associated with the plastic additive. The one or more environmental attribute(s) associated with the plastic additive may be associated with the one or more input material(s) and/or the chemical process(s) used to produce the plastic additive. The decentral identifier may relate to any identifier uniquely associated with the plastic additive. The decentral identifier may be associated with the physical entity of the plastic additive. The decentral identifier may refer to a single batch of plastic additive. The decentral identifier may be associated with a group of plastic additives. The identifier may refer to multiple physical entities of the plastic additive. The decentral identifier may be associated with continuous or semi-continuous stream of plastic additive. The identifier may refer to a stream of the plastic additive e.g. over a certain time period or from a certain supplier.

In one embodiment the one or more environmental attribute(s) associated with the plastic additive(s) are provided from at least one balancing account configured to store environmental attribute(s) associated with input material(s). The balancing account may relate to storage structure associated with metadata, such as an environmental attribute type. For instance, the balancing account may be associated with metadata indicating the environmental attribute type to be recycled-content or bio-based. An inbound allocator may be configured to allocate the one or more environmental attribute(s) associated with input material(s) to at least one balancing account e.g. on entry of the input material to the chemical production network. The balancing account may be associated with the respective environmental attribute type. An outbound assigner may be configured to assign at least one environmental attribute from the at least one balancing account associated with the respective environmental attribute to the decentral identifier. One or more environmental attribute(s) may be assigned to the at least one decentral identifier. Assignment may include de-allocation of the one or more environmental attributes from the balancing account associated with the respective environmental attribute type. By using the balancing accounts environmental attributes of input materials can be reliably tracked and assigned to plastic additives.

In one embodiment the one or more environmental attribute(s) associated with the plastic additive(s) are provided from at least one balancing account configured to store environmental attribute(s) associated with input material(s). An inbound allocator may be configured to allocate the one or more environmental attribute(s) to at least one balancing account associated with the respective environmental attribute, e.g. on input material entering the chemical production network. The balancing account may be associated with the respective environmental attribute type. The one or more environmental attribute(s) associated with the input materials may be allocated to the balancing account associated with the respective environmental attribute type. An outbound assigner may be configured to assign or link at least one environmental attribute from the at least one balancing account associated with the respective environmental attribute type to the decentral identifier. This may include de-allocation of the one or more environmental attribute(es) from the balancing account associated with the respective environmental attribute type. By using the balancing accounts environmental attributes can be tracked through the chemical production network. This way the environmental attributes may be detached from the material flow. Attribution of environmental attribute(s) may be conducted on a mass balance basis for the chemical production network. In such approach the total mass of input materials and plastic additives as well as the attribution of respective environmental attribute(s) associated with input materials and plastic additives are balanced.

In one embodiment the one or more environmental attribute(s) are associated with at least one property related to the environmental impact of the one or more input material(s) and/or the chemical process(s). The one or more environmental attribute(s) may specify environmental
5 properties of the input material(s) used to produce the plastic additive and/or the one or more environmental attribute(s) may specify environmental properties of the chemical process(es) used to produce the plastic additive. The one or more environmental attribute(s) may be generated from environmental properties of the input material(s) used to produce the plastic additive, process data associated with the chemical processing of the input material(s) and/or energy
10 data associated with the energy consumption of the chemical processing. The one or more environmental attribute(s) may include a recycled content associated with the input material(s) and allocated or allocatable to the plastic additive(s), a renewable content associated with the input material(s) and allocated or allocatable to the plastic additive(s), and/or a product carbon footprint associated with the plastic additive(s).

15 In one embodiment the production operating apparatus is configured to gather environmental attributes associated with the produced plastic additive before, during and/or after production of the plastic additive by the chemical production network. The environmental attributes associated with the produced plastic additive may relate to input material(s). The environmental attributes
20 associated with input materials may be provided before, during and/or after production of the plastic additive by the chemical production network. The environmental attributes associated with input materials may be allocated to at least one balancing account before, during and/or after production of the plastic additive by the chemical production network. The environmental attributes associated with the produced plastic additive may relate to environmental properties
25 generated from process data associated with the chemical processing of the input material(s) and/or energy data associated with the energy consumption of the chemical processing. The environmental attributes associated with the produced plastic additive may be generated before, during and/or after production of the plastic additive by the chemical production network. The process data associated with the chemical processing of the input material(s) and/or energy
30 data associated with the energy consumption of the chemical processing may be gathered prior, during and/or after production of the plastic additive.

In one embodiment the plastic additive passport or the digital asset include the decentral identifier associated with the plastic additive and the one or more environmental attribute(s) linked to
35 the decentral identifier. The one or more environmental attribute(s) may be linked to the decentral identifier included the plastic additive passport or the digital asset. The one or more environmental attribute(s) may be stored in a data base of the plastic additive producer for access

by any plastic additive user. The one or more environmental attribute(s) may be stored in a data base of the plastic additive producer for transfer to a plastic additive user e.g. when accessed or on providing the plastics additive. The decentral identifier may comprise any unique identifier uniquely associated with the plastic additive producer and plastic additive data such as the environmental attributes. The decentral identifier may include a Universally Unique Identifier (UUID) or a Digital Identifier (DID). The decentral identifier may be issued by a central or decentral identity issuer. The decentral identifier may be linked to authentication and/or authorization information. Via the decentral identifier and its unique association with the plastic additive producer and plastic additive data, such as the environmental attributes, access to the plastic additive data may be controlled by the plastic additive producer. This contrasts with central authority schemes, where identifiers are provided by such central authority and access to data is controlled by such central authority. Decentral in this context refers to the usage of the identifier in implementation as controlled by the data owner, such as the plastic additive producer.

The decentral identifier may be uniquely associated with the plastic additive or the physical entity of the plastic additive, e.g. as packaged for transportation to the plastic additive user. The decentral identifier may be uniquely to the one or more environmental attribute(s). The plastic additive passport or the digital asset may include or be connected to or be linked to one or more digital representation(s) pointing to plastic additive data including the environmental attribute(s) or parts thereof including the environmental attribute(s). The digital representation may comprise or be connected to or be linked to at least one interface to a data providing service. It may further include or be connected to or be linked to at least one interface to a data consuming service. It may include an endpoint for data exchange or sharing (resource endpoint) or an endpoint for service interaction (service endpoint), that is uniquely identified via a communication protocol. The digital representation(s) pointing to plastic additive data or parts thereof may be uniquely associated with the decentral identifier.

The plastic additive passport or the digital asset may comprise or be connected to a digital representation of plastic additive data, such as environmental attribute(s). The digital representation may include a representation for accessing the plastic additive data, such as environmental attribute(s) or part thereof. The digital representation may include a representation of plastic additive data, such as environmental attribute(s). The plastic additive passport or the digital asset may include or be connected to data related to the plastic additive data, such as environmental attribute(s), the authentication information and the decentral identifier. The data related to the plastic additive data, such as environmental attribute(s) may include the digital representation of the plastic additive data, such as environmental attribute(s).

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the present disclosure is further described with reference to the enclosed figures:

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Fig. 1 illustrates schematically an example of a chemical production network producing one or more output material(s) from one or more input material(s) in connection with a production operating system including an attribute management system.

Fig. 2 illustrates schematically an example of attributing environmental attributes of input materials to output materials of the chemical production network.

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Fig. 3 illustrates schematically an example of attributing environmental attributes of input materials and chemical processes to an output material of the chemical production network.

Fig. 4 illustrates schematically another example of a method or apparatus for providing environmental attributes associated with output materials to a material user as data consumer via a decentral network.

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Fig. 5 illustrates schematically another example of a method or apparatus for providing environmental attributes of output materials across value chains via the decentral network.

Fig. 6 illustrates schematically an example of a chemical production network for producing plastic additives associated with the digital asset.

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Fig. 1 illustrates an example of a chemical production network 102 producing one or more output material, in particular plastic additive(s) 104 from one or more input material(s) 100 in connection with a production operating system 106 including an attribute management system.

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For producing one or more output material(s), in particular plastic additive(s) 104 different input materials 100 may be provided as physical inputs to the chemical production network 102. The physical input and output material(s), in particular plastic additive(s) 100, 104 may be associated with one or more properties related to environmental impact. The properties related to environmental impact may be digitalized in the form of environmental attributes such as recycled or bio-based content of the input materials. The production operating system 106 may be configured to ingest such environmental attributes and to track the environmental attributes across the chemical production network 102 from input materials 100 to output material(s), in particular plastic additive(s) 104.

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The chemical production network 102 may include multiple interlinked processing steps. The chemical production network 102 may be an integrated chemical production network 102 with interrelated production chains. The chemical production network 102 may include multiple different production chains that have at least one intermediate product in common. The chemical
5 production network 102 may include multiple stages of the chemical value chain. The chemical production network 102 may include the producing, refining, processing and/or purification of gas or crude oil. The chemical production network 102 may include a stream cracker, or a syn-gas plant connected to multiple production chains that output chemical products 104 from the effluent of such plants. The chemical production network 102 may include multiple production
10 chains that output from one or more input material(s) 100 one or more output material(s), in particular plastic additive(s). The chemical production network 102 may include multiple tiers of a chemical value chain. The chemical production network 102 may include a physically interconnected arrangement of production sites. The production sites may be at the same location or at different locations. In the latter case the production sites may be interconnected by means of
15 dedicated transportation systems such as pipelines, supply chain vehicles, like trucks, supply chain ships or other cargo transportation means.

The chemical production network 102 may chemically convert input materials 100 to one or more output material(s), in particular plastic additive(s) 104. The chemical production network
20 102 may convert input materials 100 by way of chemical conversion to one or more output material(s), in particular plastic additive(s) 104.

The input materials 100 may be fed to the chemical production network 102 at any entry point. The input materials 100 may be fed to the chemical production network 102 at the start of the
25 chemical production network 102. Input materials 100 may for example make up the feedstock of a steam cracker. The input material 100 may include non-fossil input material, such as bio-based or recycled material, and/or fossil input material for the manufacture of chemical intermediates and chemical output material(s), in particular plastic additive(s) 104.

30 The chemical production network 102 may include multiple production steps. The production steps included in the chemical production network 102 may be defined by the system boundary of the chemical production network 102. The system boundary may be defined by location or control over production processes. The system boundary may be defined by the site of the chemical production network 102. The system boundary may be defined by production pro-
35 cesses controlled by one entity or multiple entities jointly. The system boundary may be defined by value chain with staggered production processes to an end product, which may be controlled by multiple entities separately. The chemical production network 102 may include a waste col-

lection and sorting step, a recycling step such as pyrolysis, a cracking step such as steam cracking, a separation step to separate intermediates of one process step and further processing steps to convert such intermediates to output material(s), in particular plastic additive(s) 104 leaving the system boundary of the chemical production network 102.

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The production operating system 106 of the chemical production network 102 may be configured to monitor and/or control the chemical production network 102 based on operating parameters of the different processes. One process step monitored and/or controlled may be the feed of input materials 100 or the release of output material(s), in particular plastic additive(s) 104. Another process step monitored and/or controlled may be the registration of environmental attributes associated with input materials 100 entering the system boundary of the chemical production network 102. Yet another process step monitored and/or controlled may be the attribution of environmental attributes to output material(s), in particular plastic additive(s) 104 produced via the chemical production network. Yet another process step monitored and/or controlled may be the management of environmental attributes associated with input materials 100 and output material(s), in particular plastic additive(s) 104 of the chemical production network 102.

The production operating system 106 may be configured to register inbound environmental attributes, to assign outbound environmental attributes. The production operating system 106 may be configured to access data related the inputs materials 100, the processes and/or the output material(s), in particular plastic additive(s) 104 of the chemical production network 102. For example, the production operating system 106 may be configured to register a recycled or bio-based content of the one or more input material(s) 100 used in the chemical production network 102 as environmental attribute. The production operating system 106 may be configured to allocate the environmental attribute to at least one balancing account associated with the recycled or bio-based content of the input materials 100. The production operating system 106 may be configured to allocate at least a part of the environmental attributes from the at least one balancing account to the at least one output material(s), in particular plastic additive(s) 104.

The production operating system 102 may be configured to handle environmental attributes related to the input and output material(s), in particular plastic additive(s) 100/104 of the chemical production network 102. For example, the production operating system 106 may be configured to determine environmental attributes associated with the use of input materials 100 impacting the environmental property of the chemical production network 102 and the output material(s), in particular plastic additive(s) 104 produced by the chemical production network 102. Further in particular, the production operating system 102 may be configured to determine environmental attributes associated with the output material(s), in particular plastic additive(s) 104.

This way the production operating system 102 may be configured to store environmental attributes in balancing accounts or to delete environmental attributes from the balancing accounts. The environmental attributes may hence be viewed as a credit that may be deposited in an account or deducted from an account related to the input and output material(s), in particular plastic additive(s) of the chemical production network 102. This way the environmental impact of the production may be tracked and/or traced.

In chemical production networks 102 multiple value chains may be linked. Additionally different input materials 100 or chemical processes impacting the environmental property of output material(s), in particular plastic additive(s) 104 produced by the chemical production network 102 may be used. Examples of input materials 100 impacting at least one environmental property of output material(s), in particular plastic additive(s) 104 produced from such input materials 100 are recycled, renewable or bio-based input materials 104. Examples of chemical processes impacting the environmental property include chemical processes using environmentally friendly technology such as carbon capture, carbon utilization or heat pumps.

Owing to the processing of chemicals in continuous or semi-continuous production and the complexity of chemical production networks 102, traceability of the input materials through the network may be hampered. In such scenarios, an equivalent environmental attribute signifying the impact on the environmental property of output material(s), in particular plastic additive(s) 104 produced by the chemical production network may be allocated to balancing accounts 122 and assigned to one or more output material(s), in particular plastic additive(s) 104 of the chemical production network 102. The environmental attributes may hence be decoupled from the physical material flow inside the chemical production network 102. Decoupling may be based on the mass balance model in that the equivalent amount assigned to the one or more output material(s), in particular plastic additive(s) may not exceed the equivalent amount provided by input materials or processes. If an equivalent amount has been allocated to the virtual account of one environmental attribute type, it may not be allocated a second time to another virtual account of the one environmental attribute type. Environmental attribute types may be recycled, bio-based, renewable or the like. Environmental attributes may be provided in the form of digital assets or plastic additive passports attached to the physical entity of the plastic additive.

Fig. 2 illustrates schematically an example of attributing environmental attributes associated with input materials 100 to output material(s), in particular plastic additive(s) 104 of the chemical production network 102.

As shown in Fig. 1 the chemical production network 102 and operations of the chemical production network 102 may be monitored and/or controlled by a production operating system 106.

The production operating system 106 may be configured to track environmental attributes from input materials 100 fed to the chemical production network 102 to output material(s), in particular plastic additive(s) 104 produced by the chemical production network 102. For tracking the operating system 106 may be configured to register environmental attributes associated with the input materials 100 provided to the chemical production network 102 and to attribute environmental attributes to output material(s), in particular plastic additive(s) 104 produced by the chemical production network 102.

The input materials 100 such as pyrolysis oil, bio-naphtha or bio-gas may be provided to the chemical production network 102. The input materials 100 may enter the chemical production network at the entry point, such as a steam cracker or a syngas plant. The input materials 100 may be used in the chemical production network 102 to produce one or more output material(s), in particular plastic additive(s) 104 from the input materials 100. output material(s), in particular plastic additive(s) 104 may be provided at exit points of the chemical production network 102. Further output material(s) may be MDI, TDI, PA6, EPS, PC, Polyols, Caprolactam, adipic acid, HMD, Polyamides.

On entry of the input material 100, input material data 108 may be provided via a communication network to a computing interface of the production operating system 106. A data provider, such as a QR code reader, may be configured to provide material data 108 related to the one or more input material(s) 100 and respective environmental attributes 108 to a computing interface configured to allocate the environmental attributes associated with the input materials 100. The material data 108 may include the input material identifier and environmental attributes associated with the input materials 100. The input material identifier may be associated with the physical entity of the input material 100 entering the chemical production network 102. The material data may be provided on, prior or after providing of the one or more input material(s) at entry points to the chemical production network 102.

The input material identifier may be linked to the environmental attribute(s) associated with the respective input material(s) 100, the amount of input material 100 and the certificate certifying the environmental attribute(s). The amount of input material may be a measured amount of input material 100 fed to a plant or storage of the chemical production network 102 for producing one or more output material(s), in particular plastic additive(s) 104 from the input material(s) 100. The input material identifier associated with the respective input material 100, the environmental attribute(s) associated with the respective input material(s) 100 and the amount of input

material(s) 100 provided to the chemical production network 102 may be provided to the production operating system 106. Such data may be provided via a communication network on entry to chemical production network 102, or the data may be transferred from a computing system to the production operating system 106.

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An inbound allocator 110 may be configured to allocate the one or more environmental attribute(s) to at least one balancing account 112 associated with the respective environmental attribute. For example, one balancing account 112 may relate to environmental attributes from recycled material and another balancing account 112 may relate to environmental attributes from bio-based material. The balancing account may be associated with the respective environmental attribute type, such as bio-based or recycled 100. Based on such association the balancing account associated with the environmental attribute type of the respective input material 100 may be selected. The environmental attributes may be allocated to the selected balancing account. For example, the account 112 for recycled material may be selected and the environmental attribute may be allocated to such account 122.

To allocate, the one or more environmental attribute(s) may be converted to balancing units and the balancing units may be allocated to the balancing account 122. The conversion may be based on a conversion factor such as mass, weight, carbon atoms, hydrogen atoms, methane equivalents or any other suitable measure for quantifying the environmental impact of the environmental attribute. The conversion factor may hence take into account the difference between producing chemical products from conventional input material(s) and producing chemical products from non-conventional input material(s) or producing chemical products from a mix of conventional and non-conventional input materials. The conversion factor may relate to differences in chemical and/or physical properties of conventional and non-conventional input material(s).

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By using the balancing accounts 112 it can be ensured that environmental attributes of input materials 100 are only used once for assignment to plastic additives 104. This way double counting on input or output is avoided to ensure positive environmental impact can be reliably tracked and assigned to plastic additives 104.

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An identifier provider 116 may be configured to provide the plastic additive identifier associated with the plastic additive produced by the chemical production network 102 and provided at the exit point from the chemical production network 102.

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An outbound assigner 114 may be configured to assign at least one environmental attribute from the at least one balancing account 112 associated with the respective environmental at-

tribute to the plastic additive identifier ID2. One or more environmental attribute(s) may be assigned to the at least one plastic additive identifier ID2. Assignment may include de-allocation of the one or more environmental attributes from the balancing account 112 associated with the respective environmental attribute type. Assignment may include converting one or more balancing unit(s) to one or more environmental attribute(s).

Assigning at least one environmental attribute associated with input material(s) to plastic additive(s) may include the linking of the plastic additives identifier ID2 with the environmental attribute. The plastic additive identifier ID2 may be associated with the physical entity of the plastic additive. This way the virtual identifier of a material may be uniquely linked to the physical material. Such linking may include a physical or virtual link of identifiers uniquely associated with the physical material. For physical linking a tag or code may be physically connected to the material, e.g., by printing a QR code on the packaging. For virtual linking different identifiers associated with the physical material may be linked. For example, an order number, a batch number, LOT number or a combination thereof may be linked.

The outbound assigner 114 may be configured to provide the environmental attributes associated with the plastic additive to a data consumer, such as a system associated with a user of the plastic additive. The outbound assigner 114 may be configured to provide the environmental attributes associated with the plastic additive to a decentral network as will be described in the example of Fig. 4. Environmental attributes may be provided via the above ID based schema in the form of digital assets or plastic additive passports associated with the physical entity of the plastic additive.

Fig. 3 illustrates schematically an example of attributing environmental attributes of input materials 100 and chemical processes to the plastic additive 104 of the chemical production network 102.

As described in the context of Figs. 1 and 2 the chemical production network 102 and operations of the chemical production network 102 may be monitored and/or controlled by a production operating system 106. Input materials 100 such as pyrolysis oil, bio-naphtha or bio-gas may be provided to the chemical production network 102. The input materials 100 may be used in the chemical production network 102 to produce one or more plastic additive(s) 104 from the input materials 100.

On entry of the input material 100, input material data 108 may be provided via a communication network to a computing interface of the production operating system 106. A data provider,

such as a QR code reader, may be configured to provide material data 108 related to the one or more input material(s) 100 and respective environmental attributes 108 to a computing interface configured to allocate the environmental attributes associated with the input materials 100. The material data 108 may include the input material identifier and environmental attributes associated with the input materials 100. The input material identifier may be associated with the physical entity of the input material 100 entering the chemical production network 102. The input material identifier may be linked to the carbon footprint of the input material 100 as environmental attribute. The material data may be provided on, prior or after providing of the one or more input material(s) at entry points to the chemical production network 102.

The inbound allocator 110 may be configured to retrieve the one or more environmental attribute(s) and to provide such attributes to the carbon footprint (CF) generator 120. A process data provider 122 may be configured to gather process data associated with the chemical processing of the input material(s) 100 to produce the plastic additive(s) 104. The process data provider 122 may be configured to gather energy data associated with the energy consumption of the chemical processing. The process data provider 122 may be configured to provide the process data and the energy data to the CF generator 120.

The CF generator 120 may be configured to determine the carbon footprint of the plastic additive produced by the chemical production network. The carbon footprint of the of the plastic additive may be determined based on the process data, the energy data and the carbon footprint of the input material(s) 100 used to produce the plastic additive.

An identifier provider 116 may be configured to provide the plastic additive identifier associated with the plastic additive produced by the chemical production network 102 and provided at the exit point from the chemical production network 102.

An outbound assigner 114 may be configured to assign the determined carbon footprint to the plastic additive identifier ID2. One or more environmental attribute(s) may be assigned to the at least one plastic additive identifier ID2, such as described in the context of Fig. 2.

The outbound assigner 114 may be configured to provide the environmental attributes, in particular the carbon footprint, associated with the plastic additive to a data consumer, such as a system associated with a user of the plastic additive. The outbound assigner 114 may be configured to provide the environmental attributes associated with the plastic additive to a decentral network as will be described in the example of Fig. 4. Environmental attributes may be provided

via the above ID based schema in the form of digital assets or plastic additive passports associated with the physical entity of the plastic additive.

Fig. 4 illustrates schematically an example of a method or apparatus for providing environmental attributes associated with plastic additives to a material user as data consumer via a decentral network.

The plastic additive 104 as produced by the chemical production network 102 may be provided in association with the digital asset as described in the context of Figs. 2 and 3. The digital asset may include the plastic additive identifier. The digital asset may include one or more environmental attribute(s) such as the product carbon footprint, recycled content or bio-based content. The digital asset may relate to one or more environmental attribute(s) such as the product carbon footprint, recycled content or bio-based content. The digital asset may include a digital representation of one or more environmental attribute(s) such as the product carbon footprint, recycled content or bio-based content.

The digital asset may further include or relate to authentication and/or authorization information linked to the plastic additive identifier. The authentication and/or authorization information may be provided for authentication and/or authorization of a data provider 208 and/or data consumer 210. The plastic additive identifier may include or relate to a decentral identifier, that is uniquely associated with the plastic additive. The decentral identifier may be connected to the digital representation of the environmental attributes. The digital representation may include a representation for accessing the environmental attributes or parts thereof. The decentral identifier may include a Universally Unique Identifier (UUID) or a Digital Identifier (DID). The decentral identifier may include any unique identifier uniquely associated with a data owner and/or plastic additive. The data owner may be the producer of the plastic additive. Via the decentral identifier and its unique association with the data owner and/or plastic additive access to the material configuration data may be controlled by the data owner.

The digital asset including the digital representation of one or more environmental attribute(s) such as the product carbon footprint, recycled content or bio-based content may be stored in a decentral data base 200. The one or more environmental attribute(s) such as the product carbon footprint, recycled content or bio-based content may be stored in a data base 202 associated with the data owner, such as the producer of the plastic additive 104.

The plastic additive 104 may be physically delivered to a user of the plastic additive. The plastic additive may be connected with a QR-code having encoded the plastic additive identifier. The

user of the plastic additive may read the QR-code through a QR-code reader 206. The plastic additive identifier may be provided to a data base 208 associated with the user of the plastic additive 104. In other embodiments the user of the plastic additive may retrieve the plastic additive identifier through the decentral data base 200.

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The data owner in this example may be the input material producer, the output material producer, the output material user, the end product producer. The data owner may comprise any entity generating data. The data generating node may be coupled to the data owner or the entity owning or producing physical products from or for which data is generated. The data may be generated by a third-party entity on behalf of the entity owning physical products from or for which data is generated.

The data consuming service may comprise computer-executable instructions for accessing and/or processing data, such as plastic additive data, associated with the data owner. The data providing service may comprise computer-executable instructions for providing and/or processing data, such as plastic additive data, associated with the data owner for accessing and/or processing by the data consuming service.

Based on the received plastic additive identifier a request to access the environmental attributes associated with the plastic additive identifier may be triggered by the data consuming service 210 as signified by arrow 212. The plastic additive identifier may be provided to the data providing service 214 of the producer of the plastic additive 104. In addition, authentication and/or authorization information may be provided.

The request may be authenticated and/or authorized to access the environmental attributes associated with the plastic additive identifier. Based on successful authorization and/or authentication access to the environmental attributes associated with the plastic additive identifier may be granted.

For access the plastic additive identifier may be provided to the data providing service 214 as signified by arrow 212. The data providing service 214 may use the received plastic additive identifier to retrieve the environmental attributes associated with the plastic additive 104 as signified by arrows 218 and 220. The environmental attributes associated with the plastic additive 104 provided to the data providing service 214 may be provided to the data consuming service 210 as signified by arrow 216. The environmental attributes associated with the plastic additive 104 may be stored in the data base 208 associated with the user of the plastic additive 104 as signified by arrow 220.

Through the output identifier or decentral identifier the environmental attributes can be uniquely associated with the plastic additive. Through the decentral network the environmental attributes may be transferred between the producer of the plastic additive and the user of the plastic additive. This way the environmental attributes can be shared with unique association to the plastic additive and without central intermediary directly between the value chain players. This allows for transparency of environmental attributes across the value chain and positive environmental impacts from plastic additives of the chemical production network can be tracked through the value chain.

Fig. 5 illustrates schematically an example of a method or apparatus for providing environmental attributes associated with plastic additives across value chains via the decentral network.

In the example of Fig. 5 a fully connected value chain including the chemical production network is illustrated. In the example, the input material provider, the plastic additive producer, the plastic additive user and the end product producer may be connected to the decentral network as described in the context of Fig. 4. Environmental attributes may be provided via the ID based schema described in the context of Figs. 2-5 in the form of digital assets or plastic additive passports associated with the physical entity of the input material, the plastic additive, any intermediate product or the end product.

The input material provider may provide the input materials such as bio-gas or pyrolysis oil. The environmental attributes of the input material may be provided through the data providing service connected to the decentral network as described in the context of Fig. 4. The plastic additive producer may produce the plastic additive from the input material(s) provided to the chemical production network. The plastic additive producer may access the environmental attributes associated with the input material through a data consuming service connected to the decentral network as described in the context of Fig. 4. The plastic additive producer may manage the environmental attributes via the production operating system as described in the context of Figs. 1 to 3. The plastic additive producer may assign the environmental attributes associated with the input materials or environmental attributes associated with the chemical production network such as the carbon footprint, to the plastic additives as described in the context of Figs. 1 to 3. The plastic additive producer may provide the environmental attributes associated with the plastic additive through the data providing service connected to the decentral network as described in the context of Fig. 4. The plastic additive user or the end product producer may access the environmental attributes associated with the plastic additive through the data consuming service connected to the decentral network as described in the context of Fig. 4.

The respective data owners in this example may be the input material producer, the output material producer, the output material user, the end product producer. The data owner may comprise any entity generating data. The data generating node may be coupled to the data owner or the entity owning or producing physical products from or for which data is generated. The data
5 may be generated by a third-party entity on behalf of the entity owning physical products from or for which data is generated.

The data consuming service may comprise computer-executable instructions for accessing and/or processing data, such as plastic additive data, associated with the data owner. The data
10 providing service may comprise computer-executable instructions for providing and/or processing data, such as plastic additive data, associated with the data owner for accessing and/or processing by the data consuming service.

In the example of Fig. 4 the decentral identifier may relate to the end product. Such decentral
15 identifier may be provided to the value chain participants. Via the end product specific decentral identifier data associated with the end product product produced from the plastic additive may be gathered across the production chain and assigned to the end product specific decentral identifier. For example, the one or more environmental attribute(s) associated with the end product may be derived from the environmental attribute(s) associated with the plastic additive,
20 the input material or any other product entity present in the value chain of the end product.

This way the environmental attributes of input materials, plastic additives and any products produced from plastic additives may be tracked through the value chain up to the end product. By tracking the environmental attributes of materials in such way the information can be made
25 transparent across the value chain while the information flow can be controlled by the participants in the supply chain. In addition, the environmental attributes can be handled according to the individual participants needs by production operating systems as described in the context of Figs. 1 to 3. Overall, such tracking enables tracking of positive environmental impact by individual supply chain participants, which makes positive environmental impacts transparent and attributable to individual supply chain participants.
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Fig. 6 illustrates schematically an example of a chemical production network for producing plastic additives associated with the digital asset.

35 In the example of Fig. 6 natural gas and biomethane may be provided to the chemical production network for producing plastic additives such as antioxidants. Biomethane and natural gas may be the input materials in this example as mixed feedstock. From biomethane and natural

gas methacrylate and other intermediate materials may be produced. From methacrylate antioxidants and other products, such as intermediate materials or output materials, may be produced.

- 5 In the example of Fig. 6 the bio-based content of biomethane as non-fossil input material may be tracked. As described in the context of Fig. 2, the biomethane content at the start of the antioxidants production chain may be registered via the production operating system 106. Here the biomethane content may be allocated to the balancing account 112 for bio-based materials. The environmental attribute of biomethane content is hence detached from the mass flows of the
- 10 chemical processing in the chemical production network 102 as illustrated in Fig. 6.

- For attribution of the biomethane content used to produce the antioxidant, the biomethane content may be determined. The biomethane content attributable to antioxidant production may be based on mass conservation attributable to the produced antioxidant. For example, only half of
- 15 the biomethane content may be attributable to the antioxidant and the other half may be attributable to other output products resulting from the biomethane as input material. The environmental attribute bio-based content may be attributed to such extend to the antioxidant.

- In the system shown in Fig. 2, the environmental attribute associated with the production of antioxidant may be attributed to the produced antioxidant by associating the decentral ID to the antioxidant and assigning the environmental attribute to the decentral ID. By linking the ID and the environmental attribute, the environmental attribute may be uniquely linked to the produced anti-oxidant. The antioxidant may be delivered to the antioxidant user. The packaging such as
- 20 lose bags with antioxidant may include a QR-code. The decentral ID may be included or encoded to the QR code. This way the antioxidant user may access the environmental attributes associated to the antioxidant via the ID based protocol described in the context of Figs. 4 and 5.
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Claims

1. A system for producing a plastic additive associated with a digital asset, the system comprising:
- a chemical production network configured to produce the plastic additive wherein the plastic additive is produced from one or more input material(s) through one or more chemical process(s) of the chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s);
 - a production operating apparatus configured to generate the digital asset by providing a decentral identifier associated with the produced plastic additive and linking the decentral identifier to the environmental attribute(s) of the one or more input material(s) and/or the one or more chemical process(s).
2. The system of claim 1, wherein the plastic additive associated with the digital asset is selected from antioxidants, UV absorbers, sterically hindered amines, light stabilizers, metal deactivators, phosphites, phosphonates, hydroxylamines and amine N-oxides, nitrones, thiosynergists, acid scavengers, nucleating agents, fillers and reinforcing agents, benzofuranones and indolinones, flame retardants, rheology modifiers and combinations thereof.
3. The system of any of the preceding claims, wherein the digital asset of the plastic additive includes mass balanced environmental attributes related to the input material(s)..
4. The system of any of the preceding claims, wherein the one or more environmental attribute(s) associated with the plastic additive are provided from at least one balancing account configured to store environmental attribute(s) associated with input material(s).
5. The system of any of the preceding claims, wherein the one or more environmental attribute(s) are associated with at least one property related to the environmental impact of the one or more input material(s) and/or the chemical process(s).
6. The system of any of the preceding claims, wherein the production operating apparatus is configured to gather environmental attributes associated with the produced plastic additive before, during and/or after production of the plastic additive by the chemical production network.

7. The system of any of the preceding claims, wherein the environmental attribute(s) associated with the plastic additive produced through chemical processes from one or more input material(s) provided to the chemical production network include the environmental attribute(s) associated with the input material(s), the chemical process(es) and/or the chemical production network(s).

8. The system of any of the preceding claims, wherein the environmental attribute(s) associated with input material(s) are provided before, during and/or after production of the plastic additive by the chemical production network, wherein the environmental attribute(s) associated with input material(s) are allocated to at least one balancing account before, during and/or after production of the plastic additive by the chemical production network.

9. The system of any of the preceding claims, wherein the environmental attribute(s) associated with the produced plastic additive relate to environmental properties generated from process data associated with the chemical processing of the input material(s) and/or energy data associated with the energy consumption of the chemical processing, wherein the environmental attribute(s) associated with the produced plastic additive are generated before, during and/or after production of the plastic additive by the chemical production network.

10. A method for producing an plastic additive associated with a digital asset, wherein the method comprises:

- producing the plastic additive from one or more input material(s) through one or more chemical process(s) of a chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s);
- generating the digital asset by providing a decentral identifier associated with the produced plastic additive and one or more environmental attribute(s) associated with the one or more input material(s) and/or the one or more chemical process(s);
- linking the decentral identifier and the one or more environmental attribute(s);
- providing the produced plastic additive in association with the digital asset.

11. A plastic additive associated with a digital asset including a decentral identifier associated with the plastic additive and linked to one or more environmental attribute(s) of the one or more input material(s) and/or the one or more chemical process(s) used to produce the plastic additive.

12. The plastic additive of claim 11, wherein the plastic additive is selected from antioxidants, UV absorbers, sterically hindered amines, light stabilizers, metal deactivators, phosphites, phosphonates, hydroxylamines and amine N-oxides, nitrones, thiosynergists, acid scavengers, nucleating agents, fillers and reinforcing agents, benzofuranones and indolinones, flame retardants, rheology modifiers and combinations thereof.

13. A method for generating a digital asset associated with an plastic additive, wherein the plastic additive is produced from one or more input material(s) through one or more chemical process(s) of a chemical production network, wherein the one or more input material(s) and/or the one or more chemical process(s) are associated with environmental attribute(s), the method comprising:

- providing a decentral identifier associated with the produced plastic additive and one or more environmental attribute(s) of the one or more input material(s) and/or the one or more chemical process(s) used to produce the plastic additive;
- linking the decentral identifier and the environmental attribute(s);
- providing the digital asset in association with the produced plastic additive, wherein the environmental attribute(s) associated with the plastic additive is made accessible to a user of the plastic additive through the digital asset.

14. A digital asset as generated according to the method of claim 13.

15. A method for using the digital asset generated according to the method of claim 13 in production of a product produced from the plastic additive associated with the digital asset or a method for using the plastic additive of any of claims 11 or 12 associated with the digital asset for producing a product from the plastic additive and deriving a digital asset associated with the product from the plastics additive digital asset.