

Description

Method for producing alkenyl succinic anhydrides

- 5 The present invention relates to a process for preparing alkenylsuccinic anhydrides, which is notable for higher conversions, higher purity of the reaction products and reduced formation of tarlike by-products, and to the use of the compounds prepared by this process.
- 10 Alkenylsuccinic anhydrides are used as starting materials for a multitude of chemical products, especially as the basis of emulsifiers, dispersants or lubricants.

Alkenylsuccinic anhydrides are prepared generally by reacting an alkene with maleic anhydride at temperatures of 150-250°C in the so-called "ene reaction". As
15 a result of the high thermal stress on the reactants during the reaction, the maleic anhydride on the one hand tends to decompose and the alkene used on the other hand tends to be oxidized or polymerized. As a result of these decomposition processes and side reactions, undesired insoluble tarlike by-products which have an adverse effect on the conversion and lead to highly colored, contaminated
20 products form during the reaction.

The prior art already describes a multitude of chemical additives which are capable of suppressing the side reactions and decomposition reactions during the ene reaction.

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US-3 412 111 describes the synthesis of alkenylsuccinic anhydrides using antioxidants. Preference is given to hydroquinone, 2,2'-di(p-hydroxyphenyl)-propane and phenothiazines.

- 30 US-3 476 774 describes sterically hindered substituted phenols which act as primary antioxidants during the preparation of alkenylsuccinic anhydrides. In particular, reference is made to the use of 4,4'-methylenabis(2,6-di-tert-butyl-phenol).

A further process for preparing polyalkenylsuccinic anhydrides is published in US-4 883 886. In this process, the formation of by-products by 1,3-dibromo-5,5-dimethylhydantoin is suppressed.

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Acidic or basic catalysts are used in DE-A-35 45 133 in order to obtain alkenylsuccinic anhydrides of high quality at low temperature in high yields. For example, titanium oxide, silicon oxide or aluminum oxide are effective here.

10 US-5 021 169 describes a process for preparing alkenylsuccinic anhydrides in which products with reduced tarlike by-products and improved color are prepared by performing the ene reaction in the presence of a tri(orthoalkylphenyl) phosphite and optionally with additional use of a sterically hindered phenolic antioxidant. The use of metal deactivators is not described.

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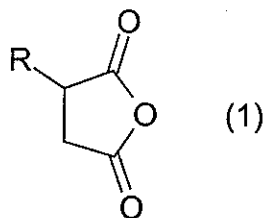
All processes for preparing alkenylsuccinic anhydrides which have already been described solve the problems of formation of tarlike by-products and the yields which are lowered as a result and the formation of highly colored products only partly. One reason for this is that the undesired side reactions, for example

20 oxidation of alkene and/or maleic anhydride or polymerization of alkene and/or maleic anhydride proceed by very complex mechanisms which have not yet been clarified completely, which can be suppressed only to a limited degree by a single additive which is capable only of suppressing one of these side reactions.

25 It is thus an object of the invention to find an additive which, in the preparation of alkenylsuccinic anhydrides, leads to the substantial prevention of formation of tarlike decomposition products, high conversions and highly pure products. Surprisingly, this aim is achieved by the use of a synergistic additive mixture which consists of a primary antioxidant, a secondary antioxidant (peroxide decomposer)

30 and a metal deactivator.

The invention therefore provides a process for preparing alkenylsuccinic anhydrides of the formula (1)



in which

R is a C₄- to C₂₅₀-alkylene radical which may be linear or branched,
by reacting maleic anhydride and an alkene which contains 4-250 carbon atoms at
5 from 150 to 250°C in the presence of 0.001 to 1.0% of a synergistic mixture of a
primary antioxidant, a peroxide decomposer and a metal deactivator.

The alkenylsuccinic anhydride thus obtained, and also the corresponding,
inevitably formed bismaleated product, are formed by this process with high
10 conversion, high purity and reduced formation of tarlike by-products.

The inventive preparation of alkenylsuccinic anhydrides with high conversion, high
purity (low coloration) and reduced formation of tarlike by-products is in principle
known in the prior art by reaction of an alkene with maleic anhydride at high
15 temperatures (from 150 to 250°C) at a reaction time of from 5 to 30 hours. For this
purpose, it is also possible to use a high-boiling inert organic solvent. Instead of
maleic anhydride, it is also possible to use maleic acid, fumaric acid or esters
thereof for the process described. The compound which forms then differs from
the compound specified in formula 1 by an acid or ester structure instead of the
20 anhydride structure specified in formula 1.

The process according to the invention can be performed at standard pressure or
at elevated pressure. A suitable alkene is preferably a *high-reactive* polyisobutene
(content of terminal double bonds > 85%) or a *low-reactive* polyisobutene (content
25 of terminal double bonds < 85%).

In order to prevent the oxidation of alkene or maleic anhydride by oxygen traces
and the polymerization of the alkene or decomposition of the maleic anhydride
induced by metal traces, for example iron or copper, in contrast to the prior art, not

only *one* antioxidant is used as an inhibitor during the ene reaction but rather a synergistic mixture of a primary antioxidant, a secondary antioxidant (peroxide decomposer) and a metal deactivator. This allows all undesired side reactions to be substantially suppressed, which is manifested in high conversions, highly pure and low-color products and significantly reduced formation of tarlike by-products. The synergistic mixture of primary antioxidant, secondary antioxidant (peroxide decomposer) and metal deactivator is added to the reactant mixture of alkene and maleic anhydride in amounts of from 0.001 to 1.0 percent by weight (% by weight), preferably from 0.05 to 0.50% by weight and more preferably from 0.10 to 0.30% by weight.

The synergistic mixture comprises from 1 to 98% primary antioxidant, from 1 to 98% secondary antioxidant and from 1 to 98% metal deactivator, preferably from 10 to 80% antioxidant, from 10 to 80% peroxide decomposer and from 10 to 80% metal deactivator, more preferably from 20 to 40% antioxidant, from 20 to 40% peroxide decomposer and from 20 to 40% metal deactivator. In a further preferred embodiment, primary antioxidant, peroxide decomposer and metal deactivator add up to 100% by weight.

Suitable primary antioxidants, secondary antioxidants and metal deactivators are described as stabilizers for macromolecular substances in Houben-Weyl, Methoden der Organischen Chemie [Methods of organic chemistry], Volume 4/1b (Oxidationen II [Oxidations II]), p. 1049-1101, and in Ullmann's Encyclopedia of Industrial Chemistry "Antioxidants: Plastics, Additives".

Preferred primary antioxidants in the synergistic mixture are

1. Sterically hindered trialkylphenols, more preferably 2,6-di-tert-butyl-4-methylphenol, bis-(2-hydroxy-5-methyl-3-tert-butylphenyl)methane or 2,4,6-tristyrylphenol.
2. Hydroquinone derivatives, more preferably hydroquinone, 4-tert-butoxyphenol or 2,5-dihydroxy-1,4-di-tert-butylbenzene.
3. Aromatic amine derivatives, more preferably 1,4-bis(2-butylamino)benzene,

4-isopropylamino-1-phenylaminobenzene or 4-butylaminophenol.

4. Aromatic heterocycles, more preferably benzimidazole, 2-mercaptobenzimidazole or phenothiazine.

5 Preferred secondary antioxidants in the synergistic mixture are:

1. Trialkyl phosphites, for example tributyl phosphite, trihexyl phosphite or trioctyl phosphite.
2. Triaryl phosphites, for example tris(2,4-di-tert-butylphenyl) phosphite, tri(nonylphenyl) phosphites or triphenyl phosphite.
3. Sulfur compounds, especially thioethers or disulfides, more preferably distearyl 3,3'-thiodipropionate, distearyl disulfide or bis(dimethylaminothiocarbonyl) disulfide.

15 Preferred metal deactivators in the synergistic mixture are:

1. N,N'-Disalicylidene-1,2-diaminopropane, N,N'-disalicylidene-1,2-diaminoethane or N,N'-disalicylidene-1,2-diaminocyclohexane
2. Salicylic acid derivatives such as salicylic acid, acetylsalicylic acid or salicylic esters
3. Hydrazine derivatives such as diacylhydrazine, N,N'-bis(3-methoxy-2-naphthoyl)hydrazine, N,N'-bisacetyl(adipic hydrazide), N,N'-dibenzaloxalyl dihydrazide or 2',3-bis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionyl]-propionohydrazide
4. Ethylenediamine-N,N,N',N'-tetraacetic acid (EDTA)
5. Tris[4,4'-thiobis(3-methyl-6-tert-butylphenol)] phosphite
6. Mannich-type reaction products formed from an alkylphenol, an aldehyde and a polyethylenepolyamine, more preferably from nonylphenol, formaldehyde and tetraethylenepentamine.

The advantage of the process according to the invention over the prior art processes will be illustrated hereinafter with reference to examples.

Examples

Example 1 (comparative)

Reaction of polyisobutene 950 and maleic anhydride (without inhibitor)

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In a 1 liter four-neck flask, 475 g (0.50 mol) of polyisobutene 950 and 63.7 g (0.65 mol) of maleic anhydride were heated to 100°C under a nitrogen atmosphere, and oxygen traces were removed by evacuating and purging with nitrogen three times with vigorous stirring.

- 10 The reaction mixture was then heated to 200°C for 18 h, then excess maleic anhydride (10.0 g) was removed by distillation and the crude product was diluted with 170 g of mineral oil. Subsequently, the product was filtered through a pressure suction filter and the residue which had been filtered off was weighed (5.7 g of black tarlike decomposition products). The hydrolysis number of the dark
- 15 brown cloudy product was 60 mg KOH/g, the residual olefin content 52% (mineral oil + unreacted polyisobutene).

Example 2 (comparative)

Reaction of polyisobutene 950 and maleic anhydride with 0.3% 2,6-di-tert-butyl-4-methylphenol (primary antioxidant, prior art)

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In a 1 liter four-neck flask, 475 g (0.50 mol) of polyisobutene 950, 63.7 g (0.65 mol) of maleic anhydride and 1.6 g (0.3% by weight) of 2,6-di-tert-butyl-4-methylphenol were heated to 100°C under a nitrogen atmosphere, and oxygen

25 traces were removed by evacuating and purging with nitrogen three times with vigorous stirring.

- The reaction mixture was then heated to 200°C for 18 h, then excess maleic anhydride (6.2 g) was removed by distillation and the crude product was diluted with 170 g of mineral oil. Subsequently, the product was filtered through a
- 30 pressure suction filter and the residue which had been filtered off was weighed (3.5 g of black tarlike decomposition products). The hydrolysis number of the dark brown cloudy product was 65 mg KOH/g, the residual olefin content 50% (mineral oil + unreacted polyisobutene).

Example 3 (comparison)

Reaction of polyisobutene 950 and maleic anhydride with 0.3% tri(2,4-di-tert-butylphenyl) phosphite (secondary antioxidant, prior art)

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In a 1 liter four-neck flask, 475 g (0.50 mol) of polyisobutene 950, 63.7 g (0.65 mol) of maleic anhydride and 1.6 g (0.3% by weight) of tri(2,4-di-tert-butylphenyl) phosphite were heated to 100°C under a nitrogen atmosphere, and oxygen traces were removed by evacuating and purging with nitrogen three times with vigorous stirring. The reaction mixture was then heated to 200°C for 18 h, then excess maleic anhydride (7.9 g) was removed by distillation and the crude product was diluted with 170 g of mineral oil. Subsequently, the product was filtered through a pressure suction filter and the residue which had been filtered off was weighed (4.3 g of black tarlike decomposition products). The hydrolysis number of the dark brown cloudy product was 64 mg KOH/g, the residual olefin content 50% (mineral oil + unreacted polyisobutene).

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Example 4

Reaction of polyisobutene 950 and maleic anhydride with 0.15% 2,6-di-tert-butyl-4-methylphenol and 0.15% tri(2,4-di-tert-butylphenyl) phosphite (mixture of prior art inhibitors)

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In a 1 liter four-neck flask, 475 g (0.50 mol) of polyisobutene 950, 63.7 g (0.65 mol) of maleic anhydride and 0.8 g (0.15% by weight) of 2,6-di-tert-butyl-4-methylphenol and 0.8 g (0.15% by weight) of tri(2,4-di-tert-butylphenyl) phosphite were heated to 100°C under a nitrogen atmosphere, and oxygen traces were removed by evacuating and purging with nitrogen three times with vigorous stirring.

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The reaction mixture was then heated to 200°C for 18 h, then excess maleic anhydride (6.8 g) was removed by distillation and the crude product was diluted with 170 g of mineral oil. Subsequently, the product was filtered through a pressure suction filter and the residue which had been filtered off was weighed (3.9 g of black tarlike decomposition products). The hydrolysis number of the dark

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brown cloudy product was 65 mg KOH/g, the residual olefin content 50% (mineral oil + unreacted polyisobutene).

Example 5 (comparative)

- 5 Reaction of polyisobutene 950 and maleic anhydride with 0.3% N,N'-disalicylidene-1,2-diaminopropane (metal deactivator)

In a 1 liter four-neck flask, 475 g (0.50 mol) of polyisobutene 950, 63.7 g (0.65 mol) of maleic anhydride and 1.6 g (0.3% by weight) of N,N'-disalicylidene-1,2-diaminopropane were heated to 100°C under a nitrogen atmosphere, and oxygen traces were removed by evacuating and purging with nitrogen three times with vigorous stirring.

The reaction mixture was then heated to 200°C for 18 h, then excess maleic anhydride (8.2 g) was removed by distillation and the crude product was diluted with 170 g of mineral oil. Subsequently, the product was filtered through a pressure suction filter and the residue which had been filtered off was weighed (5.9 g of black tarlike decomposition products). The hydrolysis number of the dark brown cloudy product was 63 mg KOH/g, the residual olefin content 51% (mineral oil + unreacted polyisobutene).

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Example 6

Reaction of polyisobutene 950 and maleic anhydride with a synergistic mixture of 0.1% 2,6-di-tert-butyl-4-methylphenol, 0.1% distearyl 3,3'-thiodipropionate and 0.05% N,N'-disalicylidene-1,2-diaminopropane

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In a 1 liter four-neck flask, 475 g (0.50 mol) of polyisobutene 950, 63.7 g (0.65 mol) of maleic anhydride and 0.54 g (0.1% by weight) of 2,6-di-tert-butyl-4-methylphenol, 0.54 g (0.1% by weight) of distearyl 3,3'-thiodipropionate and 0.27 g (0.05% by weight) of N,N'-disalicylidene-1,2-diaminopropane were heated to 100°C under a nitrogen atmosphere, and oxygen traces were removed by evacuating and purging with nitrogen three times with vigorous stirring.

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The reaction mixture was then heated to 200°C for 18 h, then excess maleic anhydride (4.4 g) was removed by distillation and the crude product was diluted

with 170 g of mineral oil. Subsequently, the product was filtered through a pressure suction filter and the residue which had been filtered off was weighed (0.8 g of black tarlike decomposition products). The hydrolysis number of the clear bright yellow product was 72 mg KOH/g, the residual olefin content 46% (mineral oil + unreacted polyisobutene).

Example 7 (comparative)

Reaction of dodecene and maleic anhydride with 0.15% 2,6-di-tert-butyl-4-methylphenol and 0.15% tri(2,4-di-tert-butylphenyl) phosphite (mixture of prior art inhibitors)

In an autoclave, 1260 g (7.5 mol) of dodecene, 490 g (5.0 mol) of maleic anhydride and 2.6 g (0.15% by weight) of 2,6-di-tert-butyl-4-methylphenol and 2.6 g (0.15% by weight) of tri(2,4-di-tert-butylphenyl) phosphite were heated to 100°C under a nitrogen atmosphere, and oxygen traces were removed by evacuating and purging with nitrogen three times with vigorous stirring. The reaction mixture was then heated to 220°C for 6 h and then unconverted dodecene and maleic anhydride were removed by distillation. Subsequently, the product was filtered through a pressure suction filter and the residue which had been filtered off was weighed (85 g of black tarlike decomposition products). The hydrolysis number of the brownish product was 395 mg KOH/g.

Example 8

Reaction of dodecene and maleic anhydride with 0.1% 2,6-di-tert-butyl-4-methylphenol, 0.1% distearyl 3,3'-thiodipropionate and 0.05% N,N'-disalicylidene-1,2-diaminopropane

In an autoclave, 1260 g (7.5 mol) of dodecene, 490 g (5.0 mol) of maleic anhydride and 1.7 g (0.1% by weight) of 2,6-di-tert-butyl-4-methylphenol and 1.7 g (0.1% by weight) of distearyl 3,3'-thiodipropionate and 0.85 g (0.05% by weight) of N,N'-disalicylidene-1,2-diaminopropane were heated to 100°C under a nitrogen atmosphere, and oxygen traces were removed by evacuating and purging with nitrogen three times with vigorous stirring.

The reaction mixture was then heated to 220°C for 6 h and then unconverted dodecene and maleic anhydride were removed by distillation. Subsequently, the product was filtered through a pressure suction filter and the residue which had been filtered off was weighed (7.5 g of black tarlike decomposition products). The hydrolysis product of the bright yellow product was 420 mg KOH/g.

The examples adduced (table 1) show clearly that the synergistic blend of primary antioxidant, secondary antioxidant and metal deactivator (example 6) is far superior to the prior art additives. Example 4 additionally demonstrates that a two-component mixture of prior art additives is clearly inferior to the inventive synergistic blend. Without the presence of a metal deactivator, the conversions and the amount of undesired tarlike by-products increase. Example 5 also shows that a metal deactivator alone is not capable of suppressing the side reactions.

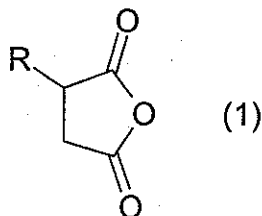
Table 1:

Product from example	HN [mg KOH/g]	Residual olefin content [%]	tarlike by-product [g]	unreacted MA [g]	Appearance
1	60	52	5.7	10	Dark brown cloudy
2	65	50	3.5	6.2	Dark brown cloudy
3	64	50	4.3	7.9	Dark brown cloudy
4	65	50	3.9	6.8	Dark brown cloudy
5	63	51	5.9	8.2	Dark brown cloudy
6	72	46	0.8	4.4	Bright yellow clear

Examples 7 and 8 were not included in table 1 since, unlike examples 1 to 6, they do not relate to polyisobutenylsuccinic anhydrides but rather to dodecenylsuccinic anhydrides.

Claims:

1. A process for preparing alkenylsuccinic anhydrides of the formula (1)



5 in which

R is a C₄- to C₂₅₀-alkylene radical which may be linear or branched, by reacting maleic anhydride and an alkene which contains 4-250 carbon atoms at from 150 to 250°C in the presence of a synergistic mixture of a primary antioxidant, a peroxide decomposer and a metal deactivator.

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2. The process as claimed in claim 1, wherein the alkenes used are tripropylene, tetrapropylene, pentapropylene or a C₈₋₃₀- α -olefin.

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3. The process as claimed in claim 1 and/or claim 2, wherein the alkene used is a polyisobutene of molar mass 550, 950, 1000, 1300 or 2300.

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4. The process as claimed in one or more of claims 1 to 3, wherein the synergistic mixture of primary antioxidant, secondary antioxidant and metal deactivator is used in an amount of from 0.001 to 1.0% by weight.

5. The process as claimed in one or more of claims 1 to 4, wherein the synergistic mixture consists of from 1 to 98% primary antioxidant, from 1 to 98% secondary antioxidant and from 1 to 98% metal deactivator.

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6. The process as claimed in one or more of claims 1 to 5, wherein the primary antioxidant used in the synergistic mixture is a sterically hindered trialkylphenol, preferably 2,6-di-tert-butyl-4-methylphenol, bis(2-hydroxy-5-trialkylphenols, preferably 2,6-di-tert-butyl-4-methylphenol, bis(2-hydroxy-5-methyl-3-tert-butylphenyl)methane or 2,4,6-tristyrylphenol.

7. The process as claimed in one or more of claims 1 to 6, wherein the primary antioxidant used in the synergistic mixture is a hydroquinone derivative, preferably hydroquinone, 4-tert-butoxyphenol or 2,5-dihydroxy-1,4-di-tert-butylbenzene.

8. The process as claimed in one or more of claims 1 to 7, wherein the primary antioxidant used in the synergistic mixture is an aromatic amine derivative, preferably 1,4-bis(2-butylamino)benzene, 4-isopropylamino-1-phenylaminobenzene or 4-butylaminophenol.

9. The process as claimed in one or more of claims 1 bis 8, wherein the primary antioxidant used in the synergistic mixture is an aromatic heterocycle, preferably benzimidazole, 2-mercaptobenzimidazole or phenothiazine.

10. The process as claimed in one or more of claims 1 to 9, wherein the secondary antioxidant used in the synergistic mixture is a trialkyl phosphite, preferably tributyl phosphite, trihexyl phosphite or trioctyl phosphite.

11. The process as claimed in one or more of claims 1 to 10, wherein the secondary antioxidant used in the synergistic mixture is a triaryl phosphite, preferably tris(2,4-di-tert-butylphenyl) phosphite, tri(nonylphenyl) phosphite or triphenyl phosphite.

12. The process as claimed in one or more of claims 1 to 11, wherein the secondary antioxidant used in the synergistic mixture is a sulfur compound, preferably distearyl 3,3'-thiodipropionate, distearyl disulfide or bis(dimethylamino-thiocarbonyl) disulfide.

13. The process as claimed in one or more of claims 1 to 12, wherein the metal deactivator used in the synergistic mixture is N,N'-disalicylidene-1,2-diaminopropane, N,N'-disalicylidene-1,2-diaminoethane or N,N'-disalicylidene-1,2-diaminocyclohexane.

14. The process as claimed in one or more of claims 1 to 13, wherein the metal deactivator used in the synergistic mixture is a salicylic acid derivative such as salicylic acid, acetylsalicylic acid or salicylic esters.

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15. The process as claimed in one or more of claims 1 to 14, wherein the metal deactivator used in the synergistic mixture is diacylhydrazine, N,N'-bis(3-methoxy-2-naphthoyl)hydrazine, N,N'-bisacetyl(adipic hydrazide), N,N'-dibenzaloxalyl dihydrazide or 2',3-bis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionyl]propionohydrazide.

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16. The process as claimed in one or more of claims 1 to 15, wherein the metal deactivator used in the synergistic mixture is ethylenediamine-N,N,N',N'-tetraacetic acid (EDTA).

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17. The process as claimed in one or more of claims 1 to 16, wherein the metal deactivator used in the synergistic mixture is tris[4,4'-thiobis(3-methyl-6-tert-butylphenol)] phosphite.

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18. The process as claimed in one or more of claims 1 to 17, wherein the metal deactivator used in the synergistic mixture is a Mannich-type reaction product formed from an alkylphenol, an aldehyde and a polyethylenepolyamine, preferably from nonylphenol, formaldehyde and tetraethylenepentamine.

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19. The process as claimed in one or more of claims 1 to 18, wherein the synergistic mixture consists of a primary antioxidant mixture and a secondary antioxidant mixture and a metal deactivator mixture.

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20. The process as claimed in one or more of claims 1 to 19, wherein the process is performed under elevated pressure.

21. The process as claimed in one or more of claims 1 to 20, wherein the molar ratio of alkene to maleic anhydride used is from 1:0.5 to 1:3.

22. The process as claimed in one or more of claims 1 to 21, wherein the ene reaction is performed in a high-boiling inert organic solvent.

5 23. The process as claimed in one or more of claims 1 to 22, wherein the alkene used is a high-reactive and/or low-reactive polyisobutene.

24. The process as claimed in one or more of claims 1 to 23, wherein maleic acid, fumaric acid or esters thereof are used instead of maleic anhydride.

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25. The use of a product produced as per one or more of claims 1 to 24 as a starting material for an emulsifier, dispersant or a lubricant, especially in the fields of metalworking, explosive emulsifiers, cosmetics or the automotive sector.