

3-Glycidyloxypropyltrialkoxysilanes having long-chain alkoxy groups, processes for production and use

5 The present invention relates to novel 3-glycidyloxypropyltrialkoxysilanes having selected long-chain alkoxy radicals, to a special process for the production thereof and to the use thereof.

EP 0773231 describes polymers functionalized using 3-glycidyloxypropyltrialkoxysilanes. When these polymers are employed in mixtures for tyre treads, the rolling resistance of tyres can be
10 reduced. These functionalized polymers are produced using 3-glycidyloxypropyltrialkoxysilanes for chain termination of the anionic polymerization. The reaction liberates inter alia the corresponding alcohol. When as described in EP 0773231 the product 3-glycidyloxypropyl-trimethoxysilane (Dynasylan® GLYMO) is employed, methanol is correspondingly liberated. Since anionic polymerizations are performed in an inert solvent, for example n-hexane or
15 cyclohexane, the alcohol liberated during chain termination must be removed from the solvent since upon reuse of the solvent the alcohol would likewise terminate the polymerization. Furthermore, methanol has a similar boiling point to the solvent n-hexane or cyclohexane and can therefore be removed to make the solvent usable again only with great difficulty/at great distillation cost and complexity.

20 Transesterification reactions as such are well-known, inter alia for alkoxy silanes. An acid is usually used as the transesterification catalyst.

DE-B 1010739 teaches the production of polysilicic esters by reaction of tetraethoxysilane with
25 higher alcohols such as cyclohexanol, methylcyclohexanol and phenols in the presence of an anhydrous or aqueous carboxylic acid as condensing agent, for example acetic or formic acid. The volatile compounds formed in the reaction, such as lower alcohol, were distilled off. The product is acid-containing.

30 US 2846459 discloses production of brominated alkyl silicates by transesterification, wherein the examples proceeded from ethyl polysilicate and the latter was reacted, inter alia, with a mixture of 2,3-dibromopropan-1-ol and 2-ethylhexanol. Catalysts used here were sodium ethoxide or a mixture of sodium methoxide and potassium carbonate. Here too, the compounds that were still volatile after the reaction, such as lower alcohol, were distilled off and hence corresponding
35 brominated alkyl silicates were obtained.

Example 7 of EP1035184A1 discloses the reaction of 100 g of ethyl silicate with 18 g of 2-ethylhexanol in the presence of sulphuric acid as catalyst. The reaction was effected over 1 hour at 120°C. Any volatile constituents still present afterwards were distilled off. This afforded
40 an alkyl silicate that still had a content of 94 mol% of ethyl and a molecular weight of 1750 g/mol. Only partial transesterification was effected here with a low yield, and the product,

furthermore, is acidic because of the residual amount of sulphuric acid used and remaining in the product. Further processing of the product was carried out in THF.

The compound 2-[[3-[tris(pentyloxy)silyl]propoxy]methyl]oxirane is mentioned in JP S62 199612 A.

2-[[3-[tris(pentyloxy)silyl]propoxy]methyl]oxirane is further discernible from DE 33 14 552 A1.

3-Glycidyloxypropyltrialkoxysilanes having long-chain alkoxy radicals as such are thus virtually undescribed.

The glycidyloxy group in 3-glycidyloxypropyltrimethoxysilane and 3-glycidyloxypropyltriethoxysilane is a very reactive group, for example toward nucleophilic compounds and in particular in the presence of an acid.

The present invention accordingly had for its object the provision of 3-glycidyloxypropyltrialkoxysilanes having long-chain alkoxy radicals and compositions comprising a high proportion of 3-glycidyloxypropyltrialkoxysilane having long-chain alkoxy radicals, including a suitable production process and optionally also a suitable possible application for corresponding products. Particular objectives included finding a nonacidic catalyst for a transesterification and thus achieving the highest possible product yield while retaining the glycidyloxy group. It was also sought to avoid the abovementioned disadvantages wherever possible or at least reduce them.

The stated object is advantageously achieved by the invention according to the features in the present claims.

In addition it is explicitly noted that all of the features, preferred ranges and cross-references to further documents described below are each combinable with one another and are accordingly disclosed in their entirety and incorporated into the present disclosure.

A special process for the production of 3-glycidyloxypropyltrialkoxysilanes having long-chain alkoxy radicals, i.e. those having more than 4 carbon atoms in the carbon chain of the alkoxy group, in particular of 3-glycidyloxypropyltri(-2-ethylhexoxy)silane and 3-glycidyloxypropyltri(-2-propylheptoxy)silane, has surprisingly now been found, where 3-glycidyloxypropyltrimethoxysilane or 3-glycidyloxypropyltriethoxysilane, a defined amount of a C5- to C16-alcohol, preferably C6- to C12-alcohol, particularly preferably C7- to C11-alcohol, most particularly preferably from the group of linear or branched C8- to C9- or C10-alcohols, preferably also those having an OH group in the ω -position, in particular 2-ethylhexanol or 2-propylheptanol, and a defined catalytic amount of titanium tetrabutoxide are brought together, the reactant mixture is heated with

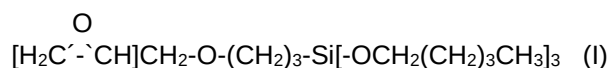
stirring to a temperature of $\leq 225^{\circ}\text{C}$ at 1 bar (atmospheric pressure), preferably to a temperature of $100 - 220^{\circ}\text{C}$, reacted and, following the reaction, methanol/ethanol and any excess long-chain alcohol present, such as 2-ethylhexanol/2-propylheptanol, are removed from the thus obtained product mixture by distillation, preferably by fractional distillation under reduced pressure, to obtain the target product/the product composition according to the invention as bottoms product in exceptional yield after distillation.

Furthermore, the composition according to the invention is not acidic and advantageously contains a content of a target compound according to the invention, in particular 3-glycidyloxypropyltri(-2-ethylhexoxy)silane/3-glycidyloxypropyltri(-2-propylheptoxy)silane, of $\geq 90\%$ by weight, and a content of free methanol/ethanol of $\leq 1\%$ by weight, in each case based on the product/the product composition.

The produced novel 3-glycidyloxypropyltrialkoxysilanes having long-chain alkoxy radicals, in particular 3-glycidyloxypropyltri(-2-ethylhexoxy)silane/3-glycidyloxypropyltri(-2-propylheptoxy)silane, may advantageously be used for terminal functionalization of solution styrene-butadiene rubber (S-SBR) and butadiene rubber (BR) during anionic polymerization and may then be readily removed from the employed solvent, such as n-hexane or cyclohexane, in order that the solvent may be reused. Moreover, rubber mixtures for tyre treads comprising a rubber functionalized with 3-glycidyloxypropyltrialkoxysilanes having long-chain alkoxy radicals feature the particular advantage that they bring about a reduction in rolling resistance of the tyres.

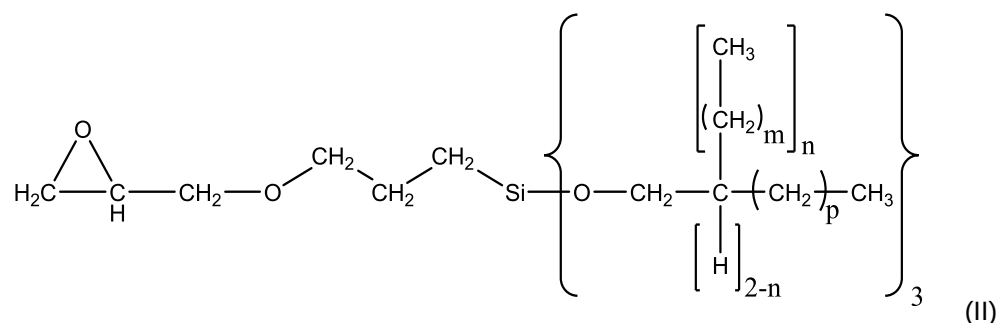
The present invention accordingly provides the compound 3-glycidyloxypropyltri(-2-propylheptoxy)silane per se.

The invention further provides a process for producing a 3-glycidyloxypropyltrialkoxysilane having long-chain alkoxy groups of general formula (I)



or

of general formula (II)

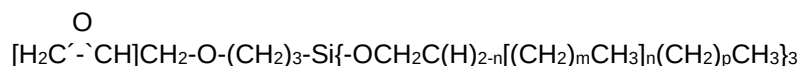


with $m=1$ or 2 , $n=0$ or 1 , $p=3, 4, 5, 6, 7, 8, 9$ or 10 , in particular 3-glycidyloxypropyltri(-2-ethylhexoxy)silane and 3-glycidyloxypropyltri(-2-propylheptoxy)silane,

where

- 5 - 3-glycidyloxypropyltrimethoxysilane or 3-glycidyloxypropyltriethoxysilane, with a stoichiometric amount or an excess of a longer-chain alcohol from the group of the C5- to C16-alcohols,
 - in the presence of titanium tetrabutoxide as catalyst,
 - is heated with stirring to a temperature of not more than 225°C,
 - 10 - reacted, and
 - following the reaction, methanol/ethanol and excess reactant alcohol, are removed from the product mixture by distillation, preferably under reduced pressure, and the product is obtained.

15 The general formula (II) can also optionally be illustrated as follows:



20 In the process according to the invention it is preferable to employ as the long-chain alcohol 2-ethylhexan-1-ol, isononanol or 2-propylheptan-1-ol, with isononanol, also referred to as isononan-1-ol or 1-isononanol, essentially representing the isomers or isomer mixtures thereof, inter alia 3,5,5-trimethyl-1-hexanol, isomeric dimethyl-1-heptanols, 7-methyloctan-1-ol, to name but a few.

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In the process according to the invention it is advantageous to employ 3-glycidyloxypropyltrimethoxysilane or 3-glycidyloxypropyltriethoxysilane and the long-chain alcohol, in particular 2-ethylhexanol and 2-propylheptanol, in a molar ratio of 1:3 to 6, preferably 1:3 to 5, particularly preferably 1:3.0 to 4, in particular 1:3.0 to 3.9. If purities >95% are required, the long-chain
30 alcohol may advantageously be employed stoichiometrically in a molar ratio of 3-glycidyloxypropyltrimethoxysilane or 3-glycidyloxypropyltriethoxysilane to long-chain alcohol of 1:3.0.

In the process according to the invention it is moreover advantageous to employ 0.01 to 0.5% by weight, preferably from 0.05% to 0.2% by weight and particularly preferably 0.1% by weight
35 of titanium tetrabutoxide based on the employed amount of 3-glycidyloxypropyltrimethoxysilane/glycidyloxypropyltriethoxysilane.

In the process according to the invention the reaction is suitably performed at a temperature of 100 to 220°C, preferably of 120 to 150°C, particularly preferably of 120 to 140°C, and over a
40 period of 6 to 24 hours, preferably of 9 to 18 hours.

The process according to the invention is generally performed as follows:

- Generally a mixture of for example 3-glycidyloxypropyltrimethoxysilane and a stoichiometric amount to relative excess by molecular weight of 2-ethylhexanol or 2-propylheptanol and also a catalytic amount of titanium tetrabutoxide are initially charged into a suitable reaction apparatus
- 5 - for example based on a reaction vessel having feeds for reactant metering, stirrer, heating means, temperature control/regulation, reflux condenser and bridge with receiver -, the mixture is heated with stirring preferably to a temperature of 100 to 220°C, in particular to a temperature in the range from 120 to 140°C, the mixture is reacted at this temperature for a sufficiently long period, preferably over 6 to 24 hours, and then following the reaction phase the volatile
- 10 components still present in the reaction mixture/product mixture thus obtained, such as methanol/ethanol, and any excess long-chain alcohol, such as 2-ethylhexanol/2-propylheptanol, are suitably distilled off under reduced pressure to work up the reaction mixture/product mixture by means of distillation and hence obtain the product/product mixture. For example, to perform the distillation, the reaction mixture/product mixture present after reaction may be transferred
- 15 from the reaction vessel into a separate distillation unit and worked up by fractional distillation. It is also possible to apply a vacuum during distillation, i.e. to distil under reduced pressure, and facultatively also to pass nitrogen through the product/product mixture present in the bottom of the distillation apparatus. The product/the composition according to the invention is thus advantageously obtained as a colourless to yellowish, slightly viscous liquid in the bottom of the
- 20 distillation apparatus used. Alternatively, the volatile alcohols, such as methanol/ ethanol and the excess long-chain alcohols, may be gently removed under vacuum using a thin-film evaporator from the product/product mixture which is advantageously collected as so-called "high boiler".
- 25 Surprisingly, performing the process according to the invention achieves in particularly advantageous fashion virtually complete transesterification with a yield of $\geq 90\%$, in particular $\geq 95\%$, and thus makes it possible, to great advantage, to provide a corresponding novel reaction product. It is thus possible by the process according to the invention advantageously to obtain novel 3-glycidyloxypropyltrialkoxysilanes having long-chain alkoxy groups according to
- 30 formula (I) and formula (II) and corresponding compositions having a high content of corresponding 3-glycidyloxypropyltrialkoxysilanes having long-chain alkoxy groups, in particular of 3-glycidyloxypropyltri(-2-ethylhexoxy)silane and 3-glycidyloxypropyltri(-2-propylheptoxy)-silane, of $\geq 90\%$ by weight, preferably $\geq 95\%$ by weight.
- 35 The present invention therefore also provides compositions having a content of 3-glycidyloxypropyltri(-2-ethylhexoxy)silane/3-glycidyloxypropyltri(-2-propylheptoxy)silane of $\geq 90\%$ by weight, preferably $\geq 95\%$ by weight, which are obtainable by the process according to the invention, wherein the components in the composition sum to 100% by weight.
- 40 The invention further provides a composition/a composition produced according to the invention

having a content of 3-glycidyloxypropyltri(-2-ethylhexoxy)silane/3-glycidyloxypropyltri(-2-propylheptoxy)silane of $\geq 90\%$ by weight, preferably $\geq 95\%$ by weight, based on the composition.

- 5 A composition according to the invention/a composition produced according to the invention preferably furthermore has a content of methanol/ethanol of $\leq 1\%$ by weight, preferably from $\leq 0.5\%$ by weight down to the detection limit, based on the composition, and thus also features, also from an environmental standpoint only, a very low proportion of VOCs (volatile organic compounds). Compositions according to the invention/compositions produced according to the
- 10 invention may also comprise a content of so-called mixed esters, preferably - but not exclusively - from the group of 3-glycidyloxypropyl-di(-2-ethylhexoxy)monomethoxysilane, 3-glycidyloxypropyl-di(-2-ethylhexoxy)monoethoxysilane, 3-glycidyloxypropylmono(-2-ethylhexoxy)-dimethoxysilane and 3-glycidyloxypropylmono(-2-ethylhexoxy)diethoxysilane, suitably with a content of mixed ester of $\leq 10\%$ by weight, preferably $\leq 5\%$ by weight, wherein all components
- 15 in a composition according to the invention/compositions produced according to the invention sum to 100% by weight.

The present invention further provides for the use of at least one of the 3-glycidyloxypropyl-trialkoxysilanes according to the invention having long-chain alkoxy groups according to

20 formula (I) and formula (II), in particular glycidyloxypropyltri(-2-ethylhexoxy)silane or 3-glycidyloxypropyltri(-2-propylheptoxy)silane, for functionalization of rubber, wherein the 3-glycidyloxypropyltrialkoxysilane having long-chain alkoxy groups, in particular 3-glycidyloxypropyltri(-2-ethylhexoxy)silane or 3-glycidyloxypropyltri(-2-propylheptoxy)silane, is preferably used for chain termination in an anionic polymerization. It is preferable to employ at least one of

25 the recited 3-glycidyloxypropyltrialkoxysilanes having long-chain alkoxy groups for functionalization/modification of rubber.

It is furthermore advantageous to use a rubber modified with at least one 3-glycidyloxypropyl-trialkoxysilane having long-chain alkoxy groups of formula (I) and of formula (II), preferably

30 3-glycidyloxypropyltri(-2-ethylhexoxy)silane or 3-glycidyloxypropyltri(-2-propylheptoxy)silane, in rubber mixtures; in particular an S-SBR or BR modified with 3-glycidyloxypropyltri(-2-ethylhexoxy)silane or 3-glycidyloxypropyltri(-2-propylheptoxy)silane in rubber mixtures for treads in tyres.

35 The novel compounds/compositions according to the invention may thus be employed in advantageous fashion for example – but not exclusively – as a coupling reagent in the production of functional polymers, such as butadiene rubber, or for solution styrene-butadiene rubber.

The present invention is elucidated in detail by the examples which follow, without restricting the subject-matter of the invention:

Examples:

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Chemicals used:

Dynasylan® GLYMO (3-glycidyloxypropyltrimethoxysilane), Evonik Resource Efficiency GmbH

Titanium tetrabutoxide, Sigma-Aldrich

2-ethylhexanol, Sigma-Aldrich

10 2-propylheptanol, Evonik Performance Materials GmbH

Analytical methods:

NMR measurements:

15 Instrument: Bruker

Frequency: 100.6 MHz (^{13}C -NMR)

Scans: 1024 (^{13}C -NMR)

Temperature: 296 K

Solvent: CDCl_3

20 Standard: tetramethylsilane

Gas chromatography determination of alcohol:

All figures should be understood as guide values. Columns of similar polarity, for example from other manufacturers, are permitted. If the separation is demonstrably also achievable with an

25 instrument having a packed column, this is also permitted.

In the handling of the samples, the moisture sensitivity thereof should be noted.

	Instrument:	Capillary gas chromatograph with TCD and integrator e.g. HP 5890 with HP 3396 integrator	
30	Separation column:	Capillary column	
	Length:	25 m	
	Internal diameter:	0.20 mm	
	Film thickness:	0.33 mm	
	Stationary phase:	HP Ultra 1	
35	Temperatures:	Column oven:	120°C - 2 min - 10°/min - 275°C - 8 min
		Injector:	250°C
		Detector:	280°C
	Carrier gas:	Helium	
		Flow:	about 1 ml/min
40		Split ratio:	ca. 1:100
	Sample injected:	0.4 ml	

Evaluation is effected by standardization to 100 area%.

5 Example 1:

Dynasylan® GLYMO (23.6 g, 100 mmol, 1.0 eq.), 2-ethylhexanol (39.1 g, 300 mmol, 3.0 eq.) and Ti(*On*Bu)₄ (23.6 mg, 0.1% by weight based on Dynasylan® GLYMO) were initially charged and heated to 130°C for 12 h. The product was then separated from volatile constituents at 130°C and 0.1 mbar. The reaction product obtained (56.1 g) was a pale yellowish, slightly viscous liquid.

10 The reaction product was analysed by means of ¹³C NMR. The analysis demonstrates that the reaction product obtained was a 3-glycidyloxypropyltri(-2-ethylhexoxy)silane.

¹³C-NMR (100 MHz, CDCl₃): δ = 74.0 (s, 1C), 71.5 (s, 1C), 64.9 (s, 3C), 50.9 (s, 1C), 44.4 (s, 1C), 41.9 (s, 3C), 30.2 (s, 3C), 29.2 (s, 3C), 23.5 (s, 3C), 23.2 (s, 3C), 14.1 (s, 3C), 11.2 (s, 3C), 6.4 (s, 15 1C) ppm.

The transesterification yield was 95%, i.e. 95% of the methoxy groups of the employed Dynasylan® GLYMO were replaced, i.e. transesterified, with 2-ethylhexoxy groups in accordance with the invention.

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Example 2:

Dynasylan® GLYMO (23.6 g, 100 mmol, 1.0 eq.), 2-ethylhexanol (50.1 g, 390 mmol, 3.9 eq.) and Ti(*On*Bu)₄ (23.6 mg, 0.1% by weight based on Dynasylan® GLYMO) were initially charged and heated to 130°C for 16 h. The product was then separated from volatile constituents at 130°C and 0.1 mbar. The reaction product obtained (57.9 g) was a pale yellowish, slightly viscous liquid.

25 The reaction product was analysed by means of ¹³C NMR. The analysis demonstrates that the reaction product obtained was a 3-glycidyloxypropyltri(-2-ethylhexoxy)silane.

30 ¹³C-NMR (100 MHz, CDCl₃): δ = 74.0 (s, 1C), 71.5 (s, 1C), 64.9 (s, 3C), 50.9 (s, 1C), 44.4 (s, 1C), 41.9 (s, 3C), 30.2 (s, 3C), 29.2 (s, 3C), 23.5 (s, 3C), 23.2 (s, 3C), 14.1 (s, 3C), 11.2 (s, 3C), 6.4 (s, 1C) ppm.

35 The transesterification yield was 98%, i.e. 98% of the methoxy groups of the employed Dynasylan® GLYMO were replaced, i.e. transesterified, with 2-ethylhexoxy groups in accordance with the invention.

Example 3:

40 Dynasylan® GLYMO (23.6 g, 100 mmol, 1.0 eq.), 2-propylheptanol (47.5 g, 300 mmol, 3.0 eq.) and Ti(*On*Bu)₄ (23.6 mg, 0.1% by weight based on Dynasylan® GLYMO) were initially charged and heated to 130°C for 12 h. The product was then separated from volatile constituents at 130°C and 0.1 mbar. The reaction product obtained (59.0 g) was a pale yellowish, slightly viscous liquid.

45 The reaction product was analysed by means of ¹³C NMR. The analysis demonstrates that the reaction product obtained was a 3-glycidyloxypropyltri(-2-propylheptoxy)silane.

^{13}C -NMR (100 MHz, CDCl_3): δ = 73.9 (s, 1C), 71.4 (s, 1C), 65.3 (s, 3C), 50.9 (s, 1C), 44.3 (s, 1C), 40.2 (s, 3C), 33.4 (s, 3C), 32.5 (s, 3C), 31.0 (s, 3C), 26.6 (s, 3C), 22.8 (s, 3C), 20.1 (s, 3C), 14.6 (s, 3C), 14.2 (s, 3C), 6.4 (s, 1C) ppm.

- 5 The transesterification yield was 96%, i.e. 96% of the methoxy groups of the employed Dynasylan® GLYMO were replaced, i.e. transesterified, with 2-propylheptoxy groups in accordance with the invention.

10 **Example 4:**

Dynasylan® GLYMO (23.6 g, 100 mmol, 1.0 eq.), 2-propylheptanol (61.7 g, 390 mmol, 3.9 eq.) and $\text{Ti}(\text{OnBu})_4$ (23.6 mg, 0.1% by weight based on Dynasylan® GLYMO) were initially charged and heated to 130°C for 18 h. The product was then separated from volatile constituents at 130°C and 0.1 mbar. The reaction product obtained (60.9 g) was a pale yellowish, slightly viscous liquid.

- 15 The reaction product was analysed by means of ^{13}C NMR. The analysis demonstrates that the reaction product obtained was a 3-glycidyloxypropyltri(-2-propylheptoxy)silane.

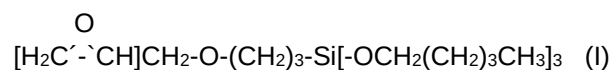
20 ^{13}C -NMR (100 MHz, CDCl_3): δ = 73.9 (s, 1C), 71.4 (s, 1C), 65.3 (s, 3C), 50.9 (s, 1C), 44.3 (s, 1C), 40.2 (s, 3C), 33.4 (s, 3C), 32.5 (s, 3C), 31.0 (s, 3C), 26.6 (s, 3C), 22.8 (s, 3C), 20.1 (s, 3C), 14.6 (s, 3C), 14.2 (s, 3C), 6.4 (s, 1C) ppm.

The transesterification yield was 99%, i.e. 99% of the methoxy groups of the employed Dynasylan® GLYMO were replaced, i.e. transesterified, with 2-propylheptoxy groups in accordance with the invention.

Claims

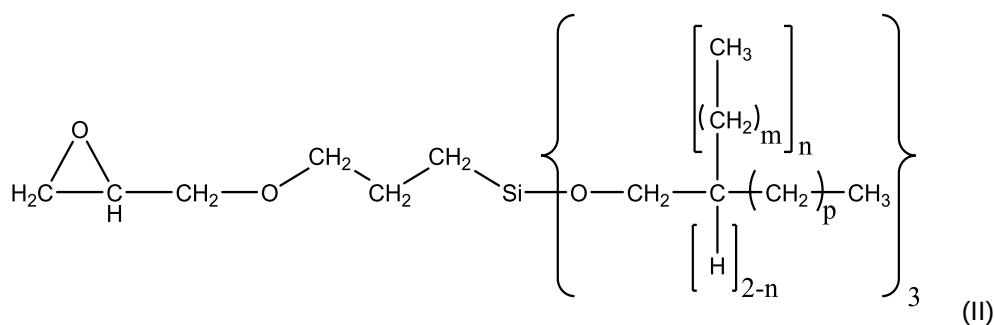
1. 3-Glycidyloxypropyltri(-2-propylheptoxy)silane.

2. Process for producing a 3-glycidyloxypropyltrialkoxysilane having long-chain alkoxy groups of general formula (I)



or

of general formula (II)



with $m = 1$ or 2 , $n = 0$ or 1 , $p = 3, 4, 5, 6, 7, 8, 9$ or 10 , in particular 3-glycidyloxypropyltri(-2-ethylhexoxy)silane and 3-glycidyloxypropyltri(-2-propylheptoxy)silane, where

- 3-glycidyloxypropyltrimethoxysilane or 3-glycidyloxypropyltriethoxysilane, with a stoichiometric amount or an excess of a longer-chain alcohol from the group of the C5- to C16-alcohols,
- in the presence of titanium tetrabutoxide as catalyst,
- is heated with stirring to a temperature of not more than 225°C ,
- reacted, and
- following the reaction, methanol/ethanol and excess reactant alcohol, are removed from the product mixture by distillation, preferably under reduced pressure, and the product is obtained.

3. Process according to Claim 2, wherein the long-chain alcohol employed is 2-ethylhexan-1-ol, isononan-1-ol or 2-propylheptan-1-ol.

4. Process according to Claim 2 or 3,

wherein glycidyloxypropyltrimethoxysilane or glycidyloxypropyltriethoxysilane and a long-

chain alcohol, in particular 2-ethylhexanol or 2-propylheptanol, are employed in a molar ratio of 1:3 to 6, preferably 1:3 to 5, particularly preferably 1:3.0 to 4, in particular 1:3.0 to 3.9.

- 5 5. Process according to any of the preceding claims,
wherein 0.01% to 0.5% by weight of titanium tetrabutoxide based on the employed amount
of 3-glycidyloxypropyltrimethoxysilane is employed, preferably from 0.05% to 0.2% by
weight, particularly preferably 0.1% by weight.
- 10 6. Process according to any of the preceding claims,
wherein the reaction is performed at a temperature of 100 to 220°C, preferably of 120 to
150°C, particularly preferably of 120-140°C.
- 15 7. Process according to any of the preceding claims,
wherein the reaction is performed over a period of 6 to 24 hours, preferably of 9 to 18
hours.
- 20 8. Process according to any of the preceding claims,
wherein the transesterification is performed with a yield of $\geq 90\%$, preferably $\geq 95\%$.
- 25 9. Process according to any of the preceding claims,
wherein a product is obtained as a composition having a content of 3-glycidyloxypropyltri(-
2-ethylhexoxy)silane/3-glycidyloxypropyltri(-2-propylheptoxy)silane of $\geq 90\%$ by weight,
preferably $\geq 95\%$ wherein the components in the composition sum to 100% by weight.
- 30 10. Composition having a content of 3-glycidyloxypropyltri(-2-ethylhexoxy)silane or 3-glycidyl-
oxypropyltri(-2-propylheptoxy)silane of $\geq 90\%$ by weight obtainable according to any one of
the preceding claims, wherein the components in the composition sum to 100% by weight.
- 35 11. Composition according to Claim 10, having a content of 3-glycidyloxypropyltri(-2-
ethylhexoxy)silane or 3-glycidyloxypropyltri(-2-propylheptoxy)silane of $\geq 90\%$ by weight,
preferably $\geq 95\%$.
12. Composition according to Claim 10 or 11, having a content of alcohols of methanol or
ethanol of $\leq 1\%$ by weight, preferably $\leq 0.5\%$ by weight, based on the composition.
- 40 13. Composition according to any of the preceding claims, having a content of mixed esters
 $\leq 10\%$ by weight, preferably $\leq 5\%$ by weight, wherein such mixed esters are preferably
selected from the group 3-glycidyloxypropyldi(-2-ethylhexoxy)monomethoxysilane,
3-glycidyloxypropyldi(-2-ethylhexoxy)monoethoxysilane, 3-glycidyloxypropylmono(-2-
ethylhexoxy)dimethoxysilane and 3-glycidyloxypropylmono(-2-ethylhexoxy)diethoxysilane.

14. Use of at least one 3-glycidyloxypropyltrialkoxysilane having long-chain alkoxy groups according to any of the preceding claims for functionalization of rubber, wherein 3-glycidyl-
oxypropyltri(-2-ethylhexoxy)silane or 3-glycidyloxypropyltri(-2-propylheptoxy)silane is
5 preferably used for chain termination in an anionic polymerization.
15. Use of at least one 3-glycidyloxypropyltrialkoxysilane having long-chain alkoxy groups according to any of the preceding claims for modifying rubber.
- 10 16. Use of a rubber modified with at least one 3-glycidyloxypropyltrialkoxysilane having long-chain alkoxy groups, preferably 3-glycidyloxypropyltri(-2-ethylhexoxy)silane or 3-glycidyl-
oxypropyltri(-2-propylheptoxy)silane, according to any of the preceding claims in rubber mixtures.
- 15 17. Use of an S-SBR oder BR modified with 3-glycidyloxypropyltri(-2-ethylhexoxy)silane or 3-glycidyloxypropyltri(-2-propylheptoxy)silane in rubber mixtures according to any of the preceding claims for treads in tyres.