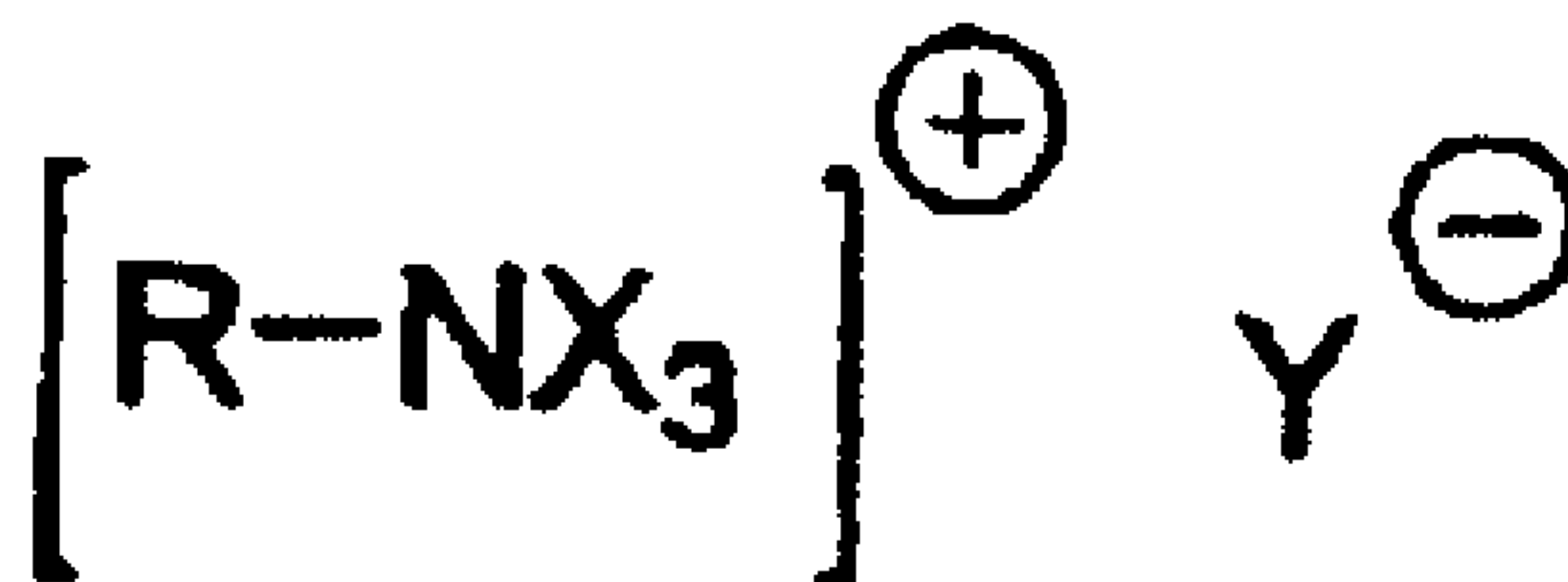




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(54) Titre : PROCEDE DE PREPARATION DE POLYISOCYANURATES RENFERMANT DES MONOMERES PEU
ODORANTS ET ENTREPOSABLES A PARTIR DE DIISOCYANATE D'ISOPHORONE
(54) Title: PROCESS FOR PREPARING LOW-ODOR AND STORAGE-STABLE MONOMER-CONTAINING
POLYISOCYANURATES FROM ISOPHORONE DIISOCYANATE



(57) Abrégé/Abstract:

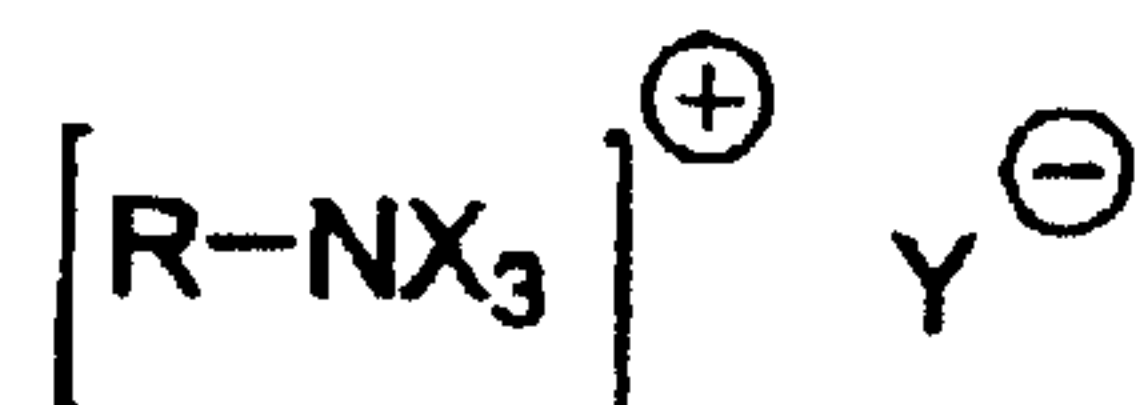
Process for preparing low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate
Process for preparing low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate by partial trimerization over a period of from 30 seconds to 2 hours in the presence of from 0.01 to 2% by weight, based on the weight of the diisocyanate, of a catalyst of the formula (see above formula) where R and X are butyl groups and Y⁻ is CH₃COO⁻, or R is a benzyl group and Y⁻ is a carboxylate anion having from 4 to 8 carbon atoms and in this case X is an alkylene group having from 2 to 3 carbon atoms, with the three radicals X together with the quaternary nitrogen forming, via a common carbon atom, a tricyclic structure which has at least one OH group in the α or β or γ position relative to the nitrogen, at a temperature of from 0 to 200°C.

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Abstract:

Process for preparing low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate

Process for preparing low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate by partial trimerization over a period of from 30 seconds to 2 hours in the presence of from 0.01 to 2% by weight, based on the weight of the diisocyanate, of a catalyst of the formula



15

where R and X are butyl groups and Y⁻ is CH₃COO⁻, or R is a benzyl group and Y⁻ is a carboxylate anion having from 4 to 8 carbon atoms and in this case X is an alkylene group having from 2 to 3 carbon atoms, with the three radicals X together with the quaternary nitrogen forming, via a common carbon atom, a tricyclic structure which has at least one OH group in the α or β or γ position relative to the nitrogen, at a temperature of from 0 to 200°C.

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Process for preparing low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate

- 5 The present invention relates to a process for preparing low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate.
- 10 Polyisocyanurates as polyisocyanate adducts are valuable components for producing high-quality coatings having good mechanical properties and good light and weather resistance. Polyisocyanurates derived from isophorone diisocyanate (IPDI) are also used as raw
- 15 material for elastomer applications. Here, it can be desirable for the IPDI-based polyisocyanurate, also referred to as IPDI trimer, to be used in monomer-containing form.
- 20 Polyisocyanurates are essentially obtained by catalytic trimerization of suitable isocyanates. Suitable isocyanates are, for example, aromatic, cycloaliphatic and aliphatic bifunctional and higher-functional polyisocyanates. Catalysts which can be used are, for
- 25 example, tertiary amines (US 3,996,223), alkali metal salts of carboxylic acids (CA 2 113 890; EP 056 159), quaternary ammonium salts (EP 798 299; EP 524 501; US 4,186,255; US 5,258,482; US 4,503,226; US 5,221,743), amino silanes (EP 197 864; US 4,697,014)
- 30 and quaternary hydroxyalkylammonium salts (EP 017 998; US 4,324,879). Depending on the catalyst, the use of various cocatalysts is also possible, e.g. O-functional compounds or Mannich bases derived from secondary amines and aldehydes or ketones.
- 35 To carry out the trimerization, the polyisocyanates are allowed to react in the presence of the catalyst, if desired with addition of solvents and/or auxiliaries, until the desired conversion has been reached. In this

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context, one also speaks of partial trimerization, since the desired conversion is generally significantly below 100%. The reaction is then stopped by deactivation of the catalyst. This is achieved by
5 addition of a catalyst inhibitor such as p-toluenesulfonic acid, hydrogen chloride or dibutyl phosphate and unavoidably results in (possibly undesirable) contamination of the resulting polyisocyanate containing isocyanurate groups. In the
10 trimerization of isocyanates on an industrial scale, the use of quaternary hydroxyalkylammonium carboxylates as oligomerization catalysts is particularly advantageous. This type of catalyst is thermally labile and allows targeted thermal deactivation, so that it is
15 not necessary to stop the trimerization by addition of potentially quality-reducing inhibitors when the desired conversion has been reached.

Monomer-containing IPDI trimer, which is suitable, for
20 example, for elastomer applications, has an NCO content of at least 25% by weight for viscosity reasons. The polyisocyanurate is prepared by partial trimerization of IPDI in the presence of one or more suitable catalysts. The catalyst then either has to be removed
25 completely from the reaction solution, which can be achieved by short-path distillation or thin-film evaporation, or be deactivated because the trimer is not storage-stable in the presence of residues of active catalyst. If the NCO content of the IPDI
30 polyisocyanurate obtained is below the desired level, it can easily be adjusted as desired by diluting the solution with monomeric IPDI.

Alkali metal salts of carboxylic acids are not well
35 suited as catalysts for the preparation of monomer-containing IPDI trimer since they can be removed from the reaction production only with difficulty, if at all. In respect of the amine-containing catalysts available, it has been found that the resulting IPDI

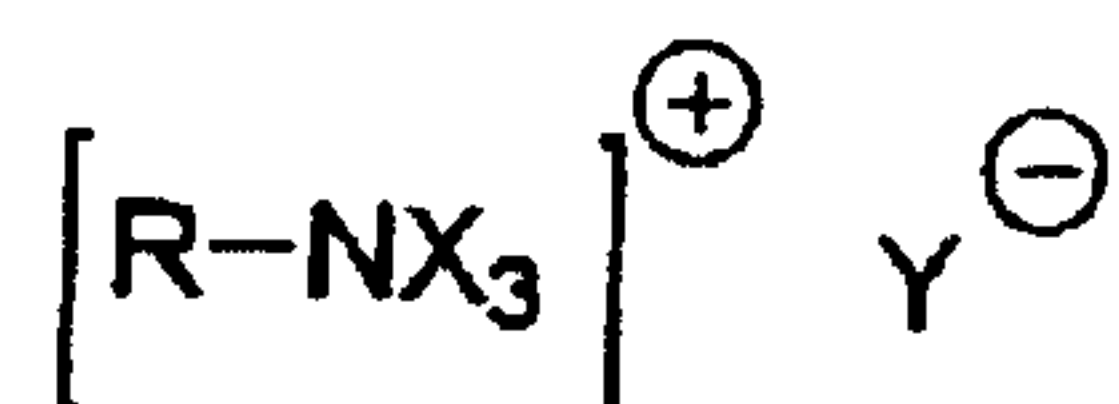
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trimer solutions essentially always have a distinctly perceptible odor which is sufficiently pronounced to be noticeable and unpleasant in the final application. In industrial practice, the undesirable odor is eliminated
 5 by freeing the reaction solution after partial trimerization and catalyst deactivation of excess IPDI, of odor-imparting components and possibly of undesirable catalyst inhibitors. This is generally achieved by short-path distillation or thin-film
 10 evaporation. The solid resin which has been freed of monomer is subsequently converted by addition of fresh IPDI into the desired, low-odor and monomer-containing IPDI polyisocyanurate.

15 The sequence of partial trimerization/deactivation, monomer removal/purification and subsequent dissolution of the solid resin in the monomer is very complicated. The monomer removal step in particular is a time-consuming and costly step and also a capacity-limiting
 20 bottleneck of the known processes. It is an object of the present invention to find a more economical process for preparing low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate which makes do without the monomer removal
 25 step.

It has surprisingly been found that this step can in actual fact be omitted and, in addition, the use of quality-reducing inhibitors can be avoided if the
 30 trimerization of IPDI is carried out in the presence of specific catalysts of the formula:

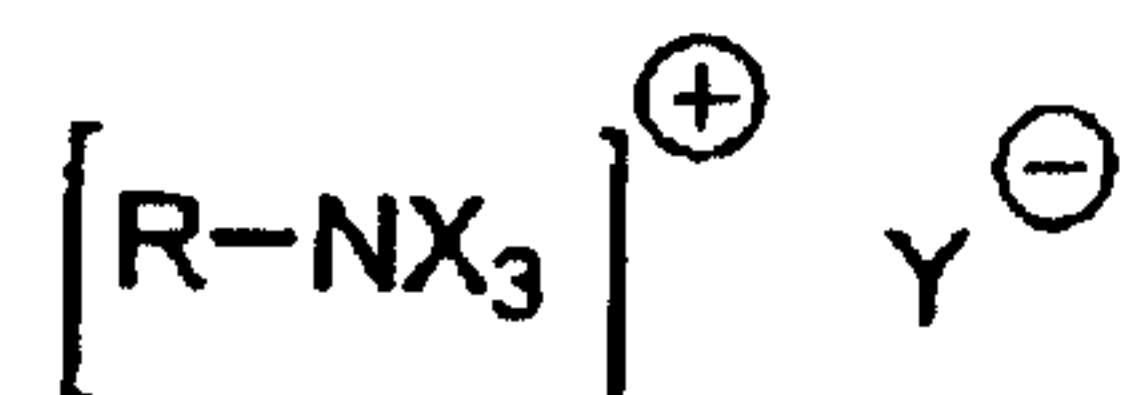


35 It could not have been foreseen that the use of the specific catalysts would enable a very economical process to be found.

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The invention accordingly provides a process for preparing low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate by partial trimerization over a period of 5 from 30 seconds to 2 hours in the presence of from 0.01 to 2% by weight, based on the weight of the diisocyanate, of a catalyst of the formula:



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where R and X are butyl groups and Y⁻ is CH₃COO⁻, or R is a benzyl group and Y⁻ is a carboxylate anion having from 4 to 8 carbon atoms and in this case X is an alkylene group having from 2 to 3 carbon atoms, with 15 the three radicals X together with the quaternary nitrogen forming, via a common carbon atom, a tricyclic structure which has at least one OH group in the α or β or γ position relative to the nitrogen, at a temperature of from 0 to 200°C. Monomer removal and 20 chemical deactivation of the trimerization catalyst can be omitted.

Isocyanates suitable for the trimerization can be prepared by various methods (Annalen der Chemie 562 25 (1949), p. 75 ff). A method which has been found particularly useful in industry is phosgenation of organic polyamines to form the corresponding polycarbamic acid chlorides and thermal dissociation of these into organic polyisocyanates and hydrogen 30 chloride. As an alternative, organic polyisocyanates can also be prepared without the use of phosgene, i.e. by phosgene-free processes. According to EP 126 299 (US 4,596,678), EP 126 300 (US 4,596,679) and EP 355 443 (US 5,087,739), (cyclo)aliphatic 35 diisocyanates such as 1-isocyanato-3-isocyanatomethyl-3,5,5-trimethylcyclohexane (isophorone diisocyanate or IPDI) can, for example, be obtained by reaction of the parent (cyclo)aliphatic diamines with urea and alcohols

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to form (cyclo)aliphatic biscarbamic esters and thermal dissociation of these into the corresponding diisocyanates and alcohols.

5 As far as the process of the invention for preparing low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate is concerned, the synthetic route by means of which the IPDI used has been prepared is unimportant. However, it
10 may be pointed out that the amount of catalyst necessary to achieve a desired NCO content is dependent, inter alia, on the quality of the raw material. Experience has shown that an increasing content of hydrolyzable chlorine compounds in the IPDI
15 makes an increase in the amount of catalyst necessary. The hydrolyzable chlorine apparently tends to have an inhibiting effect on the catalyst.

To prepare the tricyclic trimerization catalysts, a
20 two-stage synthetic route can be employed. In the first step, the parent tertiary tricyclic amine is quaternized by means of a benzylating agent. Suitable benzylating agents are, for example, benzyl chloride, benzyl bromide, benzyl iodide, benzyl tosylate or
25 benzyl triflate, while a suitable amine is, for example, 3-hydroxyquinuclidine. The quaternization occurs at from 0°C to 100°C and can be carried out in the presence or absence of solvents. The solvent-based process is generally preferred.

30 In the second step, the quaternary, tricyclic ammonium salt obtained is converted into the desired catalyst. For this purpose, a basic ion exchange resin (e.g. Amberlyst*, Dowex* or Sephadex*) is activated with aqueous
35 potassium hydroxide or aqueous sodium hydroxide and loaded with the desired carboxylic acid. Examples of suitable carboxylic acids are pivalic acid, hexanoic acid, 2-ethylhexanoic acid, adipic acid and succinic acid. The quaternary ammonium salt is then introduced
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onto the chromatographic column and eluted. The eluate comprises the desired quaternary ammonium carboxylate. The solvent can be removed by application of vacuum. In the case of the quaternary ammonium halides, the catalysts can also be obtained in very pure form by cation exchange in solution if the silver carboxylates of the specified carboxylic acids are used as reactants. It is also possible to convert the quaternary ammonium salts firstly into the corresponding quaternary ammonium hydroxides by means of ion exchange chromatography and then to convert these into the quaternary ammonium carboxylates by reaction with the desired carboxylic acid, possibly with the removal of the water liberated.

The preparation according to the invention of the low-odor and storage-stable monomer-containing polyisocyanurates from isophorone diisocyanate by partial trimerization can be carried out continuously (tube reactor or reactor cascade) or batchwise. The catalyst is used in a low concentration in the range from 0.01 to 2% by weight. The precise amount can easily be determined experimentally and depends on the catalyst, on the intended conversion, on the quality of the IPDI used and on the way in which the process is carried out.

The partial trimerization can be carried out over a period of from 30 seconds to 2 hours. In addition to monomeric IPDI, the product comprises compounds which have one or perhaps more isocyanurate rings. Compounds having a uretdione structure may also be present in small amounts as by-products. Compounds of this type are described in the literature.

According to the invention, the catalyst is used in an amount of from 0.01 to 2% by weight, preferably from 0.04 to 1% by weight, based on the weight of the isophorone diisocyanate used. The process of the

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invention is carried out at temperatures in the range from 0°C to 200°C, preferably from 20°C and 180°C, either batchwise or continuously. The batch process is preferred.

5

The batch process is carried out in a stirred reactor. Here, the mixture of isophorone diisocyanate and catalyst is usually placed in the reactor at room temperature. The temperature of the reaction mixture is subsequently increased to from 40 to 140°C, preferably to from 55 to 100°C, so as to initiate the trimerization. As an alternative, the catalyst can also be introduced after the IPDI has reached the temperature necessary for the reaction. However, this variant is not preferred. The trimerization is exothermic. The catalyst can be used in pure form, but it is also possible to dissolve the catalyst in a suitable solvent and to introduce it in this form.

20 The continuous trimerization is advantageously carried out in a reaction loop with continuous, uniform metered addition of IPDI and the catalyst at from 40 to 180°C and over a period of from 30 seconds to 10 minutes. A reaction loop having a small diameter leads to high flow velocities and consequently to good mixing. It is also advantageous to heat the IPDI/catalyst mixture to from about 50 to 60°C before introduction into the reaction loop. For more precise metering and optimal mixing of the catalyst, it is also advantageous to dissolve the catalyst in a suitable solvent. Suitable solvents are in principle all those in which the catalyst has a good solubility, e.g. water, low molecular alcohols such as methanol or low molecular weight organic acids such as acetic acid or hexanoic acid.

35

The continuous trimerization can also be carried out in a reactor cascade. A combination of a reactor cascade and a tube reactor is also conceivable.

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A preferable temperature profile of the process of the invention is such that the reaction solution reaches a temperature of from 140 to 180°C, more preferably from 140 to 160°C. In this way it can be ensured that the product prepared according to the invention meets the criterion of storage stability and thus does not gel during prolonged storage.

Preferably, the process is conducted in an inert gas atmosphere such as nitrogen.

The low-odor and storage-stable monomer-containing polyisocyanurates prepared according to the invention from isophorone diisocyanate have an NCO content of at least 25%, preferably from 25 to 34% by weight. They are useful intermediates for polyurethane coatings and elastomer applications. In these applications, they can also be used in a form which has been blocked by means of blocking agents. Suitable blocking agents are, for example, lactams such as ϵ -caprolactam, oximes such as methyl ethyl ketoxime or butanone oxime, triazoles such as 1H-1,2,4-triazole, readily enolizable compounds such as ethyl acetoacetate or acetylacetone or else malonic acid derivatives such as diesters or malonic acid.

Examples

A. Catalyst preparation

A.1. Preparation of N-benzyl-3-hydroxyquinuclidinium

2-ethylhexanoate

In a three-necked flask fitted with Claisen attachment, mechanical stirrer attachment, dropping funnel and gas inlet and gas outlet, benzyl bromide (0.3 mol; 35.1 g) was added dropwise at room temperature to a solution of

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3-hydroxyquinuclidine (0.25 mol; 31.8 g) in acetone (1000 ml) over a period of 5 minutes while stirring. The mixture was stirred for 24 hours at room temperature, the precipitate was filtered off, washed with a little acetone and the product was
5 dried at 30°C in an oil pump vacuum. This gave 60.2 g (81%) of

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N-benzyl-3-hydroxyquinuclidinium bromide as a white powder which was dissolved in 500 ml of MeOH.

5 A chromatography column (diameter about 3.5 cm) was charged with Dowex* 1X8-50 and supplied in succession with an aqueous 1M NaOH solution, distilled water, a 35% strength solution of 2-ethylhexanoic acid in methanol and finally the methanolic solution of the quaternary ammonium bromide. The catalyst was eluted
10 with MeOH, and the eluate was evaporated under reduced pressure. Yield: 78.2 g (87%) of N-benzyl-3-hydroxyquinuclidinium 2-ethylhexanoate as a white powder.

15 **B. Trimerization: Examples 1 to 5 and Comparative Examples 1 to 5**

The reactions were carried out under an N₂ atmosphere.

20 **B.1. Trimerization of IPDI using N-benzyl-3-hydroxyquinuclidinium 2-ethylhexanoate**

800 g of IPDI were admixed at room temperature with 4.0 g (0.5% by weight) of N-benzyl-3-hydroxyquinuclidinium 2-ethylhexanoate. The temperature of the mechanically stirred reaction mixture was
25 increased at a gradient of from 2.5 to 3.0°C/min until a temperature of 160°C had been reached. The mixture was subsequently allowed to cool to room temperature. The NCO content of the low-odor reaction product was 29.2% and remained stable even after heating at 50°C
30 (12 h).

B.2. Trimerization of IPDI using N-benzyl-3-hydroxyquinuclidinium 2-ethylhexanoate/MeOH

800 g of IPDI were admixed at room temperature with
35 5.3 g (0.5% by weight based on the solvent-free catalyst) of a 75% strength solution of N-benzyl-3-hydroxyquinuclidinium 2-ethylhexanoate in methanol. The temperature of the mechanically stirred reaction mixture was increased at a gradient of from 2.5 to
* Trademark

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3°C/min until a temperature of 160°C had been reached. The mixture was subsequently allowed to cool to room temperature. The NCO content of the low-odor reaction product was 28.4% and remained stable even after heating at 50°C (12 h) (a slight NCO loss due to allophanate formation was observed).

B.3. Trimerization of IPDI using tetrabutylammonium acetate

1500 g of IPDI were admixed at room temperature with 1.06 g (0.07% by weight) of tetrabutylammonium acetate (TBAAc). The temperature of the mechanically stirred reaction mixture was increased at a gradient of from 2.5 to 3°C/min. After a temperature peak of 158°C had been reached, the reaction was complete. The mixture was allowed to cool to room temperature. The NCO content of the low-odor reaction product was 28.3% and remained stable even after heating at 50°C (12 h).

B.4. Trimerization of IPDI using tetrabutylammonium acetate/MeOH

1500 g of IPDI were admixed at room temperature with 1.41 g (0.07% by weight based on the solvent-free catalyst) of a 75% strength solution of tetrabutylammonium acetate (TBAAc) in methanol. The temperature of the mechanically stirred reaction mixture was increased at a gradient of from 2.5 to 3°C/min. After a temperature peak of 167°C had been reached, the reaction was complete. The mixture was allowed to cool to room temperature. The NCO content of the low-odor reaction product was 27.0% and remained stable even after heating at 50°C (12 h) (a slight NCO loss due to allophanate formation was observed).

B.5. Trimerization of IPDI using tetrabutylammonium acetate/MeOH

800 g of IPDI were admixed at 100°C with 0.72 g (0.07% by weight based on the solvent-free catalyst) of a 75% strength solution of tetrabutylammonium acetate (TBAAc)

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in methanol, after which the temperature of the reaction mixture rose to a peak of 151°C over a period of 6 minutes. The mixture was allowed to cool to room temperature. The NCO content of the low-odor reaction product was 27.8% and remained stable even after heating at 50°C (12 h) (a slight NCO loss due to allophanate formation was observed).

Comparative Examples

10

C.1. Trimerization of IPDI using Dabco TMR®

1500 g of IPDI were admixed at 80°C with 3.75 g (0.25% by weight) of Dabco TMR® (N-(2-hydroxypropyl)-N,N,N-trimethylammonium 2-ethylhexanoate, about 75% strength in diethylene glycol). Owing to the strongly exothermic nature of the reaction, the temperature of the mechanically stirred reaction mixture rose to a peak of 136°C over a period of about 3 minutes. The mixture was allowed to cool to room temperature. The NCO content of the reaction product, which smelled strongly of amine, was 28.9% and remained stable even after heating at 50°C (12 h).

To eliminate the odor problem, unreacted IPDI was separated from the polyisocyanate by short-path evaporation. After dilution of the now monomer-free resin with fresh IPDI to an NCO content of 29.6%, a low-odor monomer-containing IPDI trimer was obtained.

C.2. Trimerization of IPDI using Dabco TMR®-2

1500 g of IPDI were admixed at 80°C with 3.75 g (0.25% by weight) of Dabco TMR®-2 (N-(2-hydroxypropyl)-N,N,N-trimethylammonium formate, about 75% strength in diethylene glycol). Owing to the strongly exothermic nature of the reaction, the temperature of the mechanically stirred reaction mixture rose to a peak of 139°C over a period of about 3 minutes. The mixture was allowed to cool to room temperature. The NCO content of the reaction product, which smelled strongly of amine,

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was 28.2% and remained stable even after heating at 50°C (12 h).

To eliminate the odor problem, unreacted IPDI was separated from the polyisocyanate by short-path evaporation. After dilution of the now monomer-free resin with fresh IPDI to an NCO content of 29.6%, a low-odor monomer-containing IPDI trimer was obtained.

10 **C.3. Trimerization of IPDI using N-(2-hydroxypropyl)-N,N,N-trimethylammonium hydroxide**

1500 g of IPDI were admixed at 80°C with 3.75 g (0.25% by weight) of N-(2-hydroxypropyl)-N,N,N-trimethylammonium hydroxide (about 75% strength in diethylene glycol). Owing to the strongly exothermic nature of the reaction, the temperature of the mechanically stirred reaction mixture rose to a peak of 143°C over a period of about 3 minutes. The mixture was allowed to cool to room temperature. The NCO content of the reaction product, which smelled strongly of amine, was 27.6% and remained stable even after heating at 50°C (12 h).

To eliminate the odor problem, unreacted IPDI was separated from the polyisocyanate by short-path evaporation. After dilution of the now monomer-free resin with fresh IPDI to an NCO content of 29.6%, a low-odor monomer-containing IPDI trimer was obtained.

30 **C.4. Trimerization of IPDI using hexamethyldisilazane (HMDS)**

1600 g of IPDI were admixed at 100°C with 1.6 g (1% by weight, 0.1 mol) of HMDS. After no conversion was observed after 30 minutes, the temperature of the mechanically stirred reaction mixture was increased to 120°C. Under these conditions, too, no appreciable conversion could be achieved. The mixture was allowed to cool to 50°C and the catalyst was deactivated by addition of 0.9 g (0.05 mol) of water. The reaction

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solution had an NCO content of 37.2% and gave off an amine-like odor. Owing to the low conversion, elimination of the odor problem by short-path evaporation and subsequent dilution of the now monomer-free resin with fresh IPDI were omitted.

C.5. Trimerization of IPDI using benzyltriethylammonium acetate

800 g of IPDI were admixed at room temperature with 1.34 g (0.17% by weight) of benzyltriethylammonium acetate in methanol. The temperature of the mechanically stirred reaction mixture was increased at a gradient of from 2.5 to 3°C/min. After a temperature peak of 149°C had been reached, the reaction was complete. The mixture was allowed to cool to room temperature. The reaction solution had an NCO content of 32.7% and gave off a distinct odor.

To eliminate the odor problem, unreacted IPDI was separated from the polyisocyanate by short-path evaporation. After dilution of the now monomer-free resin with fresh IPDI to an NCO content of 29.6%, a low-odor monomer-containing IPDI trimer was obtained.

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Table 1 Trimerization of IPDI (Examples B.1 - B.5 and Comparative Examples C.1 - C.5)

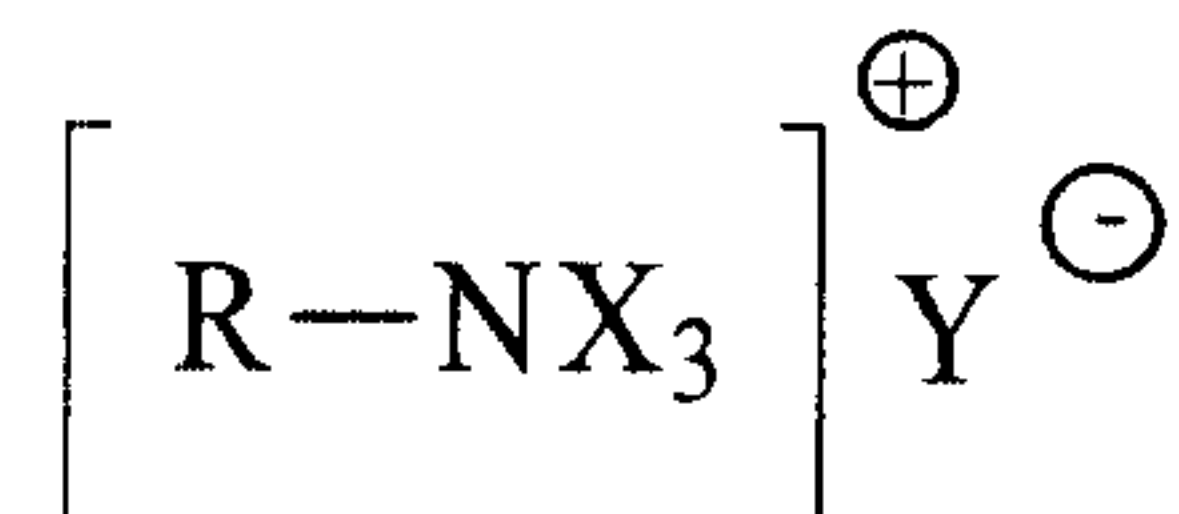
Experiment	Category	Catalyst	Amount of catalyst [% by weight]	NCO content [% by weight]	Comments
B.1.	Example	N-benzyl-3-hydroxyquinuclidinium 2-ethylhexanoate	0.5	29.2	storage-stable, low in odor
B.2.	Example	N-benzyl-3-hydroxyquinuclidinium 2-ethylhexanoate /MeOH	0.5	28.4	storage-stable, low in odor
B.3.	Example	Tetrabutylammonium acetate	0.07	28.3	storage-stable, low in odor
B.4.	Example	Tetrabutylammonium acetate/MeOH	0.07	27.0	storage-stable, low in odor
B.5.	Example	Tetrabutylammonium acetate/MeOH	0.07	27.8	storage-stable, low in odor
C.1.	Comparative example	Dabco TMR®	0.25	28.9	storage-stable, distinct odor
C.2.	Comparative example	Dabco TMR®-2	0.25	28.2	storage-stable, distinct odor
C.3.	Comparative example	N-(2-hydroxypropyl)-N,N,N-trimethylammonium hydroxide	0.25	27.6	storage-stable, distinct odor
C.4.	Comparative example	Hexamethyldisilazane	1.0	37.2	storage-stable, distinct odor
C.5.	Comparative example	Benzyltriethylammonium acetate	0.17	32.7	storage-stable, distinct odor

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CLAIMS:

1. A process for preparing a low-odor and storage-stable monomer-containing polyisocyanurate, which comprises a partial trimerization of isophorone diisocyanate over a period of from 5 30 seconds to 2 hours in the presence of from 0.01 to 2% by weight, based on the weight of the diisocyanate, of a catalyst of the formula:



10 (where R and X are each a butyl group and Y⁻ is CH₃COO⁻, or R is a benzyl group and Y⁻ is a carboxylate anion having from 4 to 8 carbon atoms and in this case X is an alkylene group having from 2 to 3 carbon atoms, with the three radicals X together with the quaternary nitrogen forming, via a common carbon atom, 15 a tricyclic structure which has at least one OH group in the α or β or γ position relative to the nitrogen), at a temperature of from 0 to 200°C.

2. The process as claimed in claim 1, wherein the catalyst used is N-benzyl-3-hydroxyquinuclidinium 2- 20 ethylhexanoate or tetrabutylammonium acetate or a mixture of the two.

3. The process as claimed in claim 1, wherein, in the formula, $\left[\text{R-NX}_3 \right]^{\oplus}$ is N-benzyl-3-hydroxyquinuclidinium and Y⁻ is a carboxylate anion having from 4 to 8 carbon atoms.

25 4. The process as claimed in claim 3, wherein the carboxylate anion is of pivalic acid, hexanoic acid, 2-ethylhexanoic acid, adipic acid or succinic acid.

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5. The process as claimed in claim 1, wherein the catalyst is N-benzyl-3-hydroxyquinuclidinium 2-ethylhexanoate.

6. The process as claimed in claim 1, wherein the catalyst is tetrabutylammonium acetate.

5 7. The process as claimed in any one of claims 1 to 6, wherein the isophorone diisocyanate has been prepared by a phosgene process or a phosgene-free process.

8. The process as claimed in any one of claims 1 to 7, wherein the storage-stable monomer-containing polyisocyanurate
10 has an NCO content of from 25 to 34% by weight.

9. The process as claimed in any one of claims 1 to 8, wherein the trimerization is carried out at from 20 to 180°C.

10. The process as claimed in claim 9, wherein the trimerization is carried out by heating the diisocyanate and
15 the catalyst so that a reaction solution reaches a temperature of 140 - 180°C due to the trimerization that is exothermic and then cooling the resulting reaction mixture.

11. The process as claimed in any one of claims 1 to 10, wherein the trimerization is carried out continuously.

20 12. The process as claimed in claim 11, wherein the continuous trimerization is conducted by using a tube reactor or a reactor cascade.

13. The process as claimed in any one of claims 1 to 5, wherein the trimerization is carried out batchwise.

25 14. The process as claimed in claim 13, wherein the batchwise trimerization is conducted in a stirred reactor.

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15. The process as claimed in any one of claims 1 to 14, which is conducted in the absence of a solvent.

16. The process as claimed in any one of claims 1 to 14, wherein the catalyst is used in a solvent.

5 17. A process for preparing a low-odor and storage-stable monomer-containing polyisocyanurate having an NCO content of at least 25% by weight, which comprises:

heating, over a period of 30 seconds to 2 hours, a reaction mixture of isophorone diisocyanate (IPDI) and 0.01 to 10 2% by weight, based on the weight of the diisocyanate, of a catalyst selected from the group consisting of:

(1) an N-benzyl-3-hydroxyquinuclidinium carboxylate in which the carboxylate has 4 to 8 carbon atoms, and

(2) tetrabutylammonium acetate, to initiate a partial 15 trimerization of IPDI that is exothermic under such conditions that a temperature of 140 - 180°C of the reaction mixture is reached, and

cooling the reaction mixture, thereby obtaining the low-odor and storage-stable monomer-containing 20 polyisocyanurate, without steps of removal of unreacted IPDI monomer after the trimerization reaction and subsequent dissolution of a solid resin in the IPDI monomer.

18. The process as claimed in claim 17, wherein the catalyst is used without or in a solvent selected from the 25 group consisting of water, a low molecular weight alcohol and a low molecular weight organic acid.

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$$\left[R - NX_3 \right]^{\oplus} Y^{\ominus}$$