Abstract: The invention describes a polyurethane or polyurethane system with adjustable gel time, which is obtainable by reacting or combining a polyisocyanate, a polyol having an average molecular weight of at least 2500 g/mol and a hydroxyl number of not more than 50, and a 1,1-bis(4-aminophenyl)cyclohexane of formula (I), wherein R is hydrogen or ethyl.
Compositions for the production of polyurethanes with adjustable gel time

Description

The present invention relates to the use of 1,1-bis(4-aminophenyl)cyclohexanes of formula

\[
\begin{align*}
\text{H}_2\text{N} & \quad \text{R} \\
\text{R} & \quad \text{R} \\
\text{H}_2\text{N} & \quad \text{R}
\end{align*}
\]

wherein \( \text{R} \) is hydrogen or ethyl,

in the production of polyurethanes with adjustable gel times.

It further relates to 1,1-bis(4-amino-3,5-diethylphenyl)cyclohexane (I, \( \text{R} = \text{C}_2\text{H}_5 \)) and a process for its production.

Polyurethanes are a large group of polymers with strongly varying compositions and properties and countless applications. In general, polyurethanes are obtained by a polyaddition reaction of H-reactive compounds such as polyether polyols or polyester polyols and diisocyanates. Processability of polyurethanes and their final properties typically depend on the molecular structure of these starting materials as well as of further covalently bound building blocks such as chain extenders or hardeners which typically are low molecular diols, triols or diamines.

An essential factor in the production of polyurethanes, in particular high performance polyurethanes and polyurethane elastomers, is gel time, which is the time period between the start of the polymerisation reaction and the first solidification of the forming polymer. Long gel times are often desired to allow for a better control of the production process. However, while the structure of educts and/or the reactivity of functional groups may have an effect on gel times, making use of specific structural
and chemical properties of compounds used in polyurethane production to adjust properties is often difficult.

Chain extenders/hardeners commonly used in the production of polyurethanes to achieve long gel times are sterically hindered diamines such as 4,4′-methylene-bis-(2,6-diethylaniline) (M-DEA) and 4,4′-methylene-bis-[3-chloro-2,6-diethylaniline] (M-CDEA) and electronically affected amines such as dimethylthiotosuenediamines and 4,4′-methylene-bis-(o-chloroaniline) (MOCA). A disadvantage of the dimethylthio-toluenediamines, however, is the yellowish colour they impart to the cured polyurethane and their unpleasant smell due to the thioether groups. On the other hand MOCA is listed as toxic.

DE-A-2013316 describes the use of specific chain extenders in the production of linear polyurethanes to modify and improve mechanical properties such as tensile strength and elongation at break. Among the various chain extenders disclosed, 1,1-bis(4-aminophenyl)cyclohexane (I, R = H) is used for the production of a polyurethane comprising an adipic acid based polyester polyol.

The object of the present invention is to provide for a precise control of the polymerization process of polyurethanes and, thus, an improved processability of the polymer.

A further object of the invention is to avoid the use of toxic listed components or of components which affect the appearance of the final polyurethane product.

According to the present invention, this object has been achieved by the use of the 1,1-bis(4-aminophenyl)cyclohexanes of formula I.

The present invention thus provides a composition suitable for the production of polyurethanes, said composition comprising:

a) a polyol having an average molecular weight of at least 2500 g/mol and a hydroxyl number of not more than 50; and
b) a 1,1-bis(4-aminophenyl)cyclohexane of formula I.

The present invention further provides a polyurethane or polyurethane system obtainable by reacting or combining:

5 a) a polyisocyanate;
b) a polyol having an average molecular weight of at least 2500 g/mol and a hydroxyl number of not more than 50; and
c) a 1,1-bis(4-aminophenyl)cyclohexane of formula I.

The invention further provides a process for the production of polyurethanes comprising reacting a polyisocyanate with a polyol having an average molecular weight of at least 2500 g/mol and a hydroxyl value of not more than 50 in the presence of a 1,1-bis(4-aminophenyl)cyclohexane of formula I to form a polyurethane.

15 The invention further relates to the use of 1,1-bis(4-aminophenyl)cyclohexanes of formula I for adjusting the gel time of polyurethanes, preferably polyurethanes based on polyether polyols.

20 It has surprisingly been found that the use of varying equivalent amounts of 1,1-bis(4-aminophenyl)cyclohexanes of formula I, and in particular the unsubstituted 1,1-bis(4-aminophenyl)cyclohexane (I, R = H; DACH), but also the ethyl-substituted 1,1-bis(4-amino-3,5-diethylphenyl)cyclohexane (I, R = Et; DDEACH), in the preparation of polyurethanes from polyols and polyisocyanates allows adjusting gel times of polyurethanes over a wide range. Gel times tailored to the individual needs of the manufacturer may thus be achieved using a single compound only. This is an unexpected finding as the unhindered amine groups of the DACH molecule could have been expected to react much faster than any sterically hindered or electronically affected primary amine groups of the compounds conventionally used to obtain long gel times.

30 Figure 1 shows the gel times of polyurethane systems comprising DACH and DDEACH in comparison with polyurethane systems comprising commercially
available aromatic diamines dependent on the equivalent ratio of reactive amine (NH$_2$) groups of the hardener to reactive hydroxyl (OH) groups of the polyol.

The polyisocyanates used in the present invention may be aromatic, alicyclic and/or aliphatic and include the polyisocyanates commonly used in the production of polyurethanes. The polyisocyanates may have two or more isocyanate groups per molecule with diisocyanates being preferred. Mixtures of two or more polyisocyanates may be used as well. Polyisocyanates useful in the invention also include modified compounds of the polyisocyanates, for example in the form of oligomers or pre-polymers as they may be obtained, for example, by reacting the polyisocyanate with small H-reactive molecules, e.g. water.

Examples of diisocyanates useful in the present invention include aliphatic and alicyclic diisocyanates such as hexamethylene diisocyanate (HDI), isophorone diisocyanate (IPDI) and 1-isocyanato-4-[(4-isocyanatocyclohexyl)methyl]cyclohexane (H12MDI), and aromatic diisocyanates such as toluylene diisocyanate (TDI), diphenylmethane diisocyanate (MDI), e.g. 4,4'-diphenylmethane diisocyanate, as well as mixtures, in particular mixtures of isomers, and more highly viscous prepolymers thereof.

Polyols useful in the present invention may have a functionality of from 2 to 4 but typically have a functionality of 2 or 3 and preferably of 2. Polyols for use in the present invention may be selected from polyols commonly used in the production of polyurethanes and include polyether polyols, polyester polyols and polyester ether polyols, with polyether polyols being preferred. The polyols used in the invention may include mixtures of two or more polyols.

Polyether polyols useful in the present invention may conventionally be prepared by catalytic polymerization of alkylene oxides using specific initiators such as alcohols or water. Suitable alkylene oxides are ethylene oxide, propylene oxide, butylene oxide or tetrahydrofuran. Polyether polyols useful in the present invention include polyethylene glycol, polypropylene glycol and polybutylene glycol. Polyether polyols based
on propylene oxide such as polypropylene glycol or block copolymers of polyethylene glycol and polypropylene glycol are preferred.

Polyester polyols useful in the present invention may be obtained from dicarboxylic acids and diols or from lactones and include the reaction products of adipic acid and polyethylene glycols (polyethylene glycol adipates) and the reaction products of the ring opening polymerization of ε-caprolactone with, e.g., diethylene glycol, 1,4-butanediol, neopentyl glycol or 1,6-hexanediol (polycaprolactone diols).

The polyols used in the present invention have an average molecular weight (the number-average molecular weight, \( M_n \)) of at least 2500 g/mol. Preferred polyols have an average molecular weight of more than 3000 g/mol, more preferably of from 3200 to 5000 g/mol and most preferably of from 3500 to 4200 g/mol, for example of from 3700 to 3900 g/mol. The hydroxyl value of the polyols used in the present invention, expressed as mg KOH/g and determined in accordance with DIN 53240, is not more than 50 and preferably is in the range of from 10 to 45, more preferably of from 15 to 40, and most preferably of from 20 to 35, for example of from 25 to 30. If the average molecular weight is below 2500 g/mol and/or the hydroxyl value is above 50, no sufficiently long gel times will be obtained.

According to a preferred embodiment of the invention, polyols such as polyether polyols have an average molecular weight of from 3200 to 5000 g/mol and a hydroxyl value of from 15 to 40, more preferably an average molecular weight of from 3500 to 4200 g/mol and a hydroxyl value of from 20 to 35.

The 1,1-bis(4-aminophenyl)cyclohexane of formula I, which may be easily obtained from cyclohexanone and the corresponding aniline, will be used in the amounts required to obtain the desired gel time. Typically, the equivalent ratio of \( \text{NH}_2 \) groups of the 1,1-bis(4-aminophenyl)cyclohexane of formula I to the OH groups of the polyol, for example the polyether polyl, is in the range of from 4:1 to 1:4 and is preferably adjusted within a range of from 3:2 to 1:4 if longer gel times are desired. In a preferred embodiment of the invention, the amount of 1,1-bis(4-aminophenyl)cyclohexane of formula I used to produce the polyurethane is adjusted so as to obtain a gel time in the
range of from 300 s to 45,000 s, preferably 750 s to 45,000 s, as determined according to DIN 16945 and DIN 16916.

In the polyurethane system of the invention, polyisocyanates, polyols and 1,1-bis(4-aminophenyl)cyclohexane of formula I are preferably present in such amounts that the equivalent ratio of NCO groups contained in the polyisocyanate to the sum of OH and NH2 groups contained in the polyol and the 1,1-bis(4-aminophenyl)cyclohexane of formula I is in the range of from 0.80:1 to 1.25:1, preferably of from 0.90:1 to 1.15:1.

Thus, when carrying out the present invention, the polyurethane system of the present invention is typically obtained by reacting or combining of from 15 to 50% by weight of polyisocyanate, 45 to 84% by weight of polyol and 1 to 15% by weight of 1,1-bis(4-aminophenyl)cyclohexane of formula I, based on a composition consisting of polyisocyanate, polyol and 1,1-bis(4-aminophenyl)cyclohexane of formula (I).

The polyurethane system or the composition of the present invention may further comprise one or more additives such as plasticizers, fillers, pigments, drying agents, light stabilizers, antioxidants, flame retardants, catalysts and mixtures thereof.

The process of the invention for the preparation of polyurethanes comprises reacting a polyisocyanate with a polyol, preferably a polyether polyol, having an average molecular weight of at least 2500 g/mol and a hydroxyl value of not more than 50 in the presence of the 1,1-bis(4-aminophenyl)cyclohexane of formula I and, optionally, in the presence of the above additives, to form the polyurethane.

According to the process of the invention, all components for the production of the polyurethanes may be mixed and reacted in one "shot". According to a preferred embodiment of the invention, the polyol is mixed in a step (a) with the 1,1-bis(4-aminophenyl)cyclohexane to obtain a homogeneous mixture. Typically, mixing is performed at a temperature of from 60 °C to 100 °C. The homogeneous mixture obtained in step (a) is then in a step (b) with the polyisocyanate to form the polyurethane. Typically, the
reaction in step (b) is carried out at a temperature of not more than 50 °C, preferably at a temperature of from 15 °C to 25 °C.

As known in the art, the polymerization reaction can be carried out solvent-free or in an inert organic solvent such as N,N-dimethylformamide (DMF) or N,N-dimethylacetamide (DMAA). Preferably, the process is carried out solvent-free.

The polyisocyanate, the polyl and the 1,1-bis(4-aminophenyl)cyclohexane may be provided as separate educts and may then be mixed and reacted to form the polyurethane. Alternatively, the polyl and the 1,1-bis(4-aminophenyl)cyclohexane may be provided in the form of a composition comprising or consisting of these components. Preferably, the composition is a homogenous mixture, and this homogenous mixture may then be mixed and reacted with the polyisocyanate to form the polyurethane.

1,1-Bis(4-amino-3,5-diethylphenyl)cyclohexane (I, \( R = \) Et; DDEACH), which is also an object of the present invention, can be prepared by reacting 2,6-diethylaniline hydrochloride with cyclohexanone. The reaction is preferably carried out using water as solvent. The reaction temperature is advantageously 60 to 150 °C, preferably 80 to 120 °C. The reaction time depends on the temperature, for example at about 100 °C the reaction typically requires several hours.

The present invention is illustrated in more detail with reference to the following examples and to Figure 1, which are not intended to limit the invention.

**Examples**

Polyurethane systems were prepared using DACH and several other known diamines as chain extenders/hardeners and the gel times were determined.

The following diamines were used:
1,1-Bis(4-aminophenyl)cyclohexane (I, \( R = H; \) DACH),
1,1-Bis(4-amino-3,5-diethylphenyl)cyclohexane (I, \( R = \) Et; DDEACH).
Ethacure® 300 (E-300; mixture of 3,5-dimethylthio-2,4-toluenediamine and 3,5-dimethylthio-2,6-toluenediamine available from Albemarle Corporation, US): 

4,4'-Methylene-bis-(3-chloro-2,6-diethylaniline) (M-CDEA):

4,4'-Methylene-bis-(o-chloroaniline) (MOCA):

For the preparation of polyurethane systems, a polyether diol based on polypropylene glycol with an OH number of 26 to 29 and an average molecular weight of 3800 g/mol (available under the trade name Voranol® EP 1900) was mixed with the above diamine compounds at 80 °C in the amounts and molar ratios given in Table 1 below. After 5 to 15 minutes at 80 °C, a homogenous viscous solution was obtained. The viscous solution was cooled to room temperature and then prepolymerized diphenylmethane diisocyanate (MDI) with an isocyanate value of 10.2% (available under the trade name Suprasec® 2008, Huntsman Corporation, US) was added in the amounts and ratios given below. The equivalent ratio of reactive amine (NH2) groups to reactive hydroxyl (OH) groups was of from 3:1 to 1:3. The final equivalent ratio of reactive NCO groups to reactive (NH2 + OH) groups was 0.95 in all examples. The gel time was measured at 25 °C after having obtained a homogenous mixture using a GELNORM® Gel Timer (Gel Instrumente AG, Thalwil, Switzerland) according to DIN 16945 Page 1 and DIN 16916. The results are summarized in Table 1.
Table 1. Gel times obtained with different amounts of diamines, polyether diol and diisocyanate.

<table>
<thead>
<tr>
<th>Example No.</th>
<th>Amine</th>
<th>Amount of amine [g]</th>
<th>Amount of diol [g]</th>
<th>Amount of isocyanate [g]</th>
<th>Ratio amine/diol (mol equivalents (NH₂/OH))</th>
<th>Isocyanate (mol equivalents NCO/(NH₂ + OH))</th>
<th>Gel time @ 25 °C [s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DACH</td>
<td>0.64</td>
<td>3.26</td>
<td>2.50</td>
<td>75/25</td>
<td>95/100</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>DACH</td>
<td>0.26</td>
<td>2.62</td>
<td>1.25</td>
<td>60/40</td>
<td>95/100</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>DACH</td>
<td>0.28</td>
<td>4.35</td>
<td>1.67</td>
<td>50/50</td>
<td>95/100</td>
<td>1260</td>
</tr>
<tr>
<td>4</td>
<td>DACH</td>
<td>0.23</td>
<td>5.26</td>
<td>1.67</td>
<td>40/60</td>
<td>95/100</td>
<td>12720</td>
</tr>
<tr>
<td>5</td>
<td>DACH</td>
<td>0.11</td>
<td>4.91</td>
<td>1.25</td>
<td>25/75</td>
<td>95/100</td>
<td>39910</td>
</tr>
<tr>
<td>6</td>
<td>DDEACH</td>
<td>0.91</td>
<td>3.26</td>
<td>2.5</td>
<td>75/25</td>
<td>95/100</td>
<td>22</td>
</tr>
<tr>
<td>7</td>
<td>DDEACH</td>
<td>0.48</td>
<td>3.49</td>
<td>1.67</td>
<td>60/40</td>
<td>95/100</td>
<td>78</td>
</tr>
<tr>
<td>8</td>
<td>DDEACH</td>
<td>0.40</td>
<td>4.35</td>
<td>1.67</td>
<td>50/50</td>
<td>95/100</td>
<td>300</td>
</tr>
<tr>
<td>9</td>
<td>DDEACH</td>
<td>0.17</td>
<td>5.45</td>
<td>1.39</td>
<td>25/75</td>
<td>95/100</td>
<td>850</td>
</tr>
<tr>
<td>10*</td>
<td>E-300</td>
<td>0.51</td>
<td>3.26</td>
<td>2.50</td>
<td>75/25</td>
<td>95/100</td>
<td>780</td>
</tr>
<tr>
<td>11*</td>
<td>E-300</td>
<td>0.34</td>
<td>4.36</td>
<td>2.08</td>
<td>60/40</td>
<td>95/100</td>
<td>1570</td>
</tr>
<tr>
<td>12*</td>
<td>E-300</td>
<td>0.23</td>
<td>4.35</td>
<td>1.67</td>
<td>50/50</td>
<td>95/100</td>
<td>2280</td>
</tr>
<tr>
<td>13*</td>
<td>E-300</td>
<td>0.18</td>
<td>5.26</td>
<td>1.67</td>
<td>40/60</td>
<td>95/100</td>
<td>4320</td>
</tr>
<tr>
<td>14*</td>
<td>E-300</td>
<td>0.09</td>
<td>5.45</td>
<td>1.39</td>
<td>25/75</td>
<td>95/100</td>
<td>10300</td>
</tr>
<tr>
<td>15*</td>
<td>M-CDEA</td>
<td>0.91</td>
<td>3.26</td>
<td>2.50</td>
<td>75/25</td>
<td>95/100</td>
<td>110</td>
</tr>
<tr>
<td>16*</td>
<td>M-CDEA</td>
<td>0.40</td>
<td>4.35</td>
<td>1.67</td>
<td>50/50</td>
<td>95/100</td>
<td>250</td>
</tr>
<tr>
<td>17*</td>
<td>M-CDEA</td>
<td>0.15</td>
<td>4.91</td>
<td>1.25</td>
<td>25/75</td>
<td>95/100</td>
<td>358</td>
</tr>
<tr>
<td>18*</td>
<td>MOCA</td>
<td>0.64</td>
<td>3.26</td>
<td>2.50</td>
<td>75/25</td>
<td>95/100</td>
<td>1860</td>
</tr>
<tr>
<td>19*</td>
<td>MOCA</td>
<td>0.32</td>
<td>4.90</td>
<td>1.88</td>
<td>50/50</td>
<td>95/100</td>
<td>27480</td>
</tr>
<tr>
<td>20*</td>
<td>MOCA</td>
<td>0.11</td>
<td>4.91</td>
<td>1.25</td>
<td>25/75</td>
<td>95/100</td>
<td>108000**</td>
</tr>
<tr>
<td>21*</td>
<td></td>
<td>—</td>
<td>5.49</td>
<td>1.39</td>
<td>0/100</td>
<td>95/100</td>
<td>108000**</td>
</tr>
</tbody>
</table>

* Comparative Example
** No gelation obtained after this time

Figure 1 is a graphical representation of the gel times obtained for DACH, E-300, MOCA and M-CDEA presented in Table 1 as a function of the equivalent ratio of amine groups to hydroxy groups in the polyurethane system.

As may be seen from the results shown in Table 1 and Fig. 1, gel times in a polyurethane system comprising DACH (Examples 1-5) considerably increase over the equivalent ratio of NH₂ groups to OH groups of from 75:25 to 25:75 used in the present examples. This allows to precisely adjusting the gel time over a wide range by varying the amount of DACH in the polyurethane system. This wide range of gel times is not obtained with any other of the tested aromatic diamines. At an equivalent ratio of 25:75, the gel time for DACH is about four times longer than the gel time for E-300 (Example 14) and approximately one hundred times longer than the gel time for
M-CDEA (Example 17). This is an unexpected finding as the unhindered amine groups of the DACH molecule could have been expected to react much faster than the sterically and electronically affected primary amine groups of M-CDEA or E-300. With the diamines according to prior art, sufficiently long gel times may only be achievable using the undesirable toxic MOCA (Examples 18-20). Also surprisingly, at low amine/diol ratios the ethyl-substituted DDEACH provides shorter gel times than the unsubstituted DACH. Although the relative gel time range available with DDEACH (ca. 40:1) is much narrower than with DACH (ca. 8000:1), it is still substantially broader than that obtainable with E-300 (ca. 13:1) or M-CDEA (ca. 3.3:1) over the same amine/diol molar equivalent ratio range.

Thus, the present invention provides a possibility to effectively adjust the gel time of polyurethanes, which is particularly advantageous in the preparation of polyurethane elastomers and high performance polyurethanes. The present invention also avoids the use of toxic compounds such as MOCA and of compounds which may affect the appearance of the final product.

The following example illustrates the preparation of 1,1-bis(4-amino-3,5-diethyl-phenyl)cyclohexane (I, R = Et; DDEACH). Gas chromatography (GC)/Mass Spectroscopy (MS) was carried out in a Hewlett Packard 5972 GC; Agilent Technologies column HP-5MS; 50 m × 0.20 mm * 0.33 μm; injection temperature: 250 °C; detection temperature: 250 °C.

GC: Bruker-430-GC; column dimensions: 15 m * 0.25 mm; stationary phase: VF-1 ms, thickness 0.25 μm.

To 2,6-diethylaniline (15.6 mL, 0.1 mol) hydrochloric acid (37 wt%, 10 mL, 0.12 mol) was slowly added. The resulting salt was dissolved by addition of water (40 mL). After addition of cyclohexanone (10.32 mL, 0.1 mol) the mixture was heated to 100 °C for 16 h. Additional cyclohexanone (5.5 mL) was added to the mixture. The reaction was stirred for additional 30 h, then cooled down to room temperature and the organic phase was extracted with methyl terf-butyl ether. The phases were separated and the aqueous phase was allowed to crystallize overnight. The solid was filtered off and washed with water (pH 6). Then the solid was suspended in 15% aqueous NaOH
solution and subjected to steam distillation. The distillate was extracted with methyl
terf-butyl ether and the organic phase was dried over anhydrous sodium sulfate. The
solvent was distilled off and the resulting grey solid was recrystallized from hexane
yielding 7.5 g (20%) of 1,1-bis(4-amino-3,5-diethylphenyl)cyclohexane (I, R = Et;
DDEACH) as a white solid (97.8 area% as determined by GC).

GC/MS: m/z 378 (M+), 349 (M+ - 29), 335 (M+ - 43).
Claims

1. A composition for the production of polyurethanes with adjustable gel time, comprising:
   a) a polyol having an average molecular weight of at least 2500 g/mol and a hydroxyl number of not more than 50; and
   b) a 1,1-bis(4-aminophenyl)cyclohexane of formula

   \[
   \begin{array}{c}
   \text{H}_2\text{N} \\
   \text{R} \\
   \text{R} \\
   \text{R} \\
   \text{NH}_2 \\
   \text{R} \\
   \end{array}
   \]

   wherein R is hydrogen or ethyl.

2. The composition of claim 1, wherein the polyol is a polyether polyol.

3. The composition of claim 2, wherein the polyether polyol is a propylene oxide-based polyether polyol.

4. The composition of any one of claims 1 to 3, wherein the polyol has an average molecular weight of from 3200 to 5000 g/mol, preferably of from 3500 to 4200 g/mol.

5. The composition of any one of claims 1 to 4, wherein the polyol has a hydroxyl number of from 15 to 40, preferably of from 20 to 35.

6. A polyurethane or polyurethane system with adjustable gel time, obtainable by reacting or combining:
   a) a polyisocyanate; and
   b) the composition of any one of claims 1 to 6.
7. The polyurethane or polyurethane system of claim 6, wherein the equivalent ratio of the NCO groups of the polyisocyanate to the sum of the OH and NH2 groups of the polyol and 1,1-bis(4-aminophenyl)cyclohexane of formula I is from 0.80:1 to 1.25:1.

8. A process for the production of polyurethanes with adjustable gel time, comprising reacting a polyisocyanate with a polyol having an average molecular weight of at least 2500 g/mol and a hydroxyl value of not more than 50 in the presence of a 1,1-bis(4-aminophenyl)cyclohexane of formula

\[
\begin{align*}
\text{H}_2\text{N} & \quad \text{R} \\
\text{R} & \quad \text{R} \\
\text{NH}_2 & \quad \text{R}
\end{align*}
\]

wherein R is hydrogen or ethyl.

9. The process of claim 8, comprising the steps of:
   (a) mixing the polyol with the 1,1-bis(4-aminophenyl)cyclohexane to obtain a homogeneous mixture; and
   (b) reacting the homogeneous mixture obtained in step (a) with the polyisocyanate to form the polyurethane.

10. The process of claim 8 or 9, wherein the mixing in step (a) is performed at a temperature of from 60 to 100 °C.
11. Use of a 1,1-bis(4-aminophenyl)cyclohexane of formula

\[
\begin{align*}
&\text{H}_2\text{N} \\
&\text{R} \\
&\text{R} \\
&\text{R} \\
&\text{R} \\
&\text{NH}_2
\end{align*}
\]

wherein \( R \) is hydrogen or ethyl,

for adjusting the gel time of polyurethanes.

12. The use of claim 11, wherein the polyurethane is a polyurethane based on a polyether polyol.

13. 1,1-Bis(4-amino-3,5-diethylphenyl)cyclohexane of formula

\[
\begin{align*}
&\text{H}_2\text{N} \\
&\text{R} \\
&\text{R} \\
&\text{R} \\
&\text{R} \\
&\text{NH}_2
\end{align*}
\]

wherein \( R \) is ethyl.

14. A process for the production of 1,1-bis(4-amino-3,5-diethylphenyl)cyclohexane, comprising the step of reacting 2,6-diethylaniline hydrochloride with cyclohexanone.

15. The process of claim 14, wherein the reaction of 2,6-diethylaniline hydrochloride with cyclohexanone is carried out in aqueous solution.