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(54) Titre : POLYISOCYANATE A BASE DE DIISOCYANATES DE 4,4'- ET DE 2,4'-DIPHENYLMETHANE ET LEUR  
UTILISATION DANS LA METHODE RIM

(54) Title: NOVEL POLYISOCYANATE BASED UPON 4,4'- AND 2,4'- DIPHENYLMETHANE DIISOCYANATES AND USE  
THEREOF IN A RIM PROCESS

(57) **Abrégé/Abstract:**

Novel liquid, room temperature polyisocyanate having isocyanate group contents of from 6 to 31% by weight, are prepared by reacting: a) a methylene-bis(phenyl isocyanate) containing 1) from 65 to 90% by weight of the 4,4'-isomer, 2) from 10 to 35% by weight of the 2,4'-isomer, and 3) no more than 2% by weight of the 2,2'-isomer, with the percents of components a)1), a)2), and a)3) totalling 100%, and b) a mixture of: 1) one or more organic compounds having molecular weights of from 400 to 6000 and containing from 2 to 8 isocyanate reactive groups, and 2) one or more organic diols having molecular weights of from 60 to 200, excluding tripropylene glycol, the weight ratio of component b)1) to b)2) being from 150:1 to 5:1. When used in a RIM process, molded products are obtained which have improved tear strength, improved flexural modulus, improved impact resistance, and improved tensile strength.



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NOVEL POLYISOCYANATE BASED UPON  
4,4'- AND 2,4'-DIPHENYLMETHANE  
DIISOCYANATES AND USE THEREOF IN A RIM PROCESS

ABSTRACT OF THE DISCLOSURE

Novel liquid, room temperature polyisocyanate having isocyanate group contents of from 6 to 31% by weight, are prepared by reacting:

- a) a methylene-bis(phenyl isocyanate) containing
  - 1) from 65 to 90% by weight of the 4,4'-isomer,
  - 2) from 10 to 35% by weight of the 2,4'-isomer, and
  - 3) no more than 2% by weight of the 2,2'-isomer, with the percents of components a)1), a)2), and a)3) totalling 100%, and
- b) a mixture of:
  - 1) one or more organic compounds having molecular weights of from 400 to 6000 and containing from 2 to 8 isocyanate reactive groups, and
  - 2) one or more organic diols having molecular weights of from 60 to 200, excluding tripropylene glycol, the weight ratio of component b)1) to b)2) being from 150:1 to 5:1.

When used in a RIM process, molded products are obtained which have improved tear strength, improved flexural modulus, improved impact resistance, and improved tensile strength.

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NOVEL POLYISOCYANATE BASED UPON  
4,4'- AND 2,4'-DIPHENYLMETHANE  
DIISOCYANATES AND USE THEREOF IN A RIM PROCESS

BACKGROUND OF THE INVENTION

5           Diisocyanates which are liquid at room temperature have numerous advantages over solid diisocyanates. The most commercially important diisocyanates which are solid at room temperature are 4,4'-diphenylmethane diisocyanate and 2,4'-diphenylmethane diisocyanate. Numerous patents have issued relating to the liquification of diphenyl-  
10   methane diisocyanates ("MDI").

          One common route to liquification of MDI is through carbodiimidization. Typical of this process are the processes described in U.S. Patents 3,152,162, 3,384,643, 3,449,256, 3,640,966, 3,641,093, 3,701,796, 4,014,935, 4,088,665, 4,154,752, and 4,177,205.

15           Other less common techniques include reaction with N,N-di-(2-hydroxypropyl)aniline (U.S. patent 3,394,165) and heating with N,N'-disubstituted thioureas (U.S. 3,674,828).

          The most common technique used to liquify MDI is through reaction with various hydroxyl functional materials. Thus, the prior art has  
20   described several types of liquid isocyanates:

- 1)       reaction products of MDI with poly-1,2-propylene ether glycols having molecular weights of from 134 to 700 (U.S. 3,644,457);
- 2)       reaction products of MDI with a mixture of alkylene glycols  
25       containing at least three carbon atoms (U.S. 3,883,571 and 4,229,347);
- 3)       mixtures of i) 30 to 80% by weight MDI, ii) 5 to 25% by weight MDI uretonimine-containing derivatives, iii) 20 to 50% by weight reaction products of MDI with diols or

- mixtures of diols having molecular weights of less than 175,  
and iv) 0 to 10% by weight polymethylene poly(phenyl  
isocyanates) (U.S. 4,031,026);
- 5            4)    reaction products of polyoxyethylene glycols of molecular  
weight of from 200 to 600 and polymethylene poly(phenyl  
isocyanates) containing from 65 to 85% by weight of MDI,  
with the balance being higher homologues (U.S. 4,055,548);
- 10           5)    reaction products of MDI with polyols having molecular  
weights of from 240 to 1500 and functionalities of from 2.7  
to 3.3 (U.S. 4,102,833);
- 6)    reaction products of MDI (of various 2,4'-isomer contents)  
with propylene glycol or poly-1,2-propylene ether glycols  
(U.S. 4,118,411) or with polyoxyethylene glycols (U.S.  
4,115,429);
- 15           7)    mixtures of i) 50 to 90% by weight reaction products of MDI  
and blends of 50 to 100% by weight of polyoxypropylene  
diols or triols having equivalent weights of from 750 to 3000  
and 0 to 50% by weight polyoxyethylene diols or triols  
having equivalent weights of from 750 to 3000, and ii) 10 to  
20           50% by weight of polymethylene poly(phenyl isocyanate)  
containing 30 to 65% of diphenylmethane diisocyanate  
(U.S. 4,261,8520;
- 25           8)    mixtures of i) reaction products of MDI and a polyol blend of  
a polyol having a molecular weight of at least 1000 and a  
polyol having a molecular weight of from 115 to 300 and ii)  
liquified MDI (U.S. 4,321,333);
- 9)    reaction products of MDI and an N-substituted ethanolamine  
(U.S. 4,332,742);

- 10) reaction products of MDI containing from 10 to 20% by weight of the 2,4-isomer and a 5500 molecular weight polyether triol (U.S. 4,448,904);
- 5 11) reaction products of MDI with a phenyl-substituted alkane diol (U.S. 4,490,300) or with a monoallyl ether of trimethylolpropane (U.S. 4,490,301);
- 12) reaction products of MDI with mixtures of monoalcohols, poly-1,2-propylene ether glycols and low molecular weight triols (U.S. 4,490,302);
- 10 13) reaction products of MDI of various isomer contents with 1,3-butane diol and propylene glycol (U.S. 4,539,156), with neopentyl glycol and propylene glycol (U.S. 4,539,157) and 1,3-butane diol and neopentyl glycol (U.S. 4,539,158);
- 15 14) reaction products of MDI with amines and tripropylene glycol (U.S. 4,883,909);
- 15) reaction products of MDI high molecular weight polyols and tripropylene glycol (U.S. 4,442,235 and 4,910,333 );
- 20 16) mixtures of i) reaction products of MDI and a polyol of equivalent weight of from 30 to 600 and ii) polymethylene poly(phenyl isocyanates) (U.S. 5,240,635); and
- 25 17) mixtures of i) reaction products of MDI and polyoxymethylene glycols of equivalent weight of from 250 to 1500, and ii) up to 30% by weight of a second isocyanate which can be the 2,4'-isomer or a polymethylene poly(phenyl isocyanate) (U.S. 5,246,977).

A variety of different molded polyurethane parts can be produced by the reaction injection molding ("RIM") process. This process involves

filling a closed mold with highly reactive liquid starting components within a very short time, generally by using high output, high pressure dosing apparatus after the components have been mixed. The RIM process has become an important process for the production of external automotive body parts and other types of molded products. The RIM process involves the intimate mixing of a polyisocyanate component and an isocyanate-reactive component, followed by the injection of this mixture into a mold for subsequent rapid curing. The polyisocyanate component is typically based on a liquid polyisocyanate. The isocyanate-reactive component contains a high molecular weight isocyanate-reactive component, typically a polyol and/or an amine polyether, and usually contains a chain extender containing amino and/or hydroxyl groups. U.S. Patent 4,218,543 describes a RIM process currently being commercially used on a large scale. U.S. Patents 4,433,067, 4,444,910, 4,530,941, 4,774,263, and 4,774,264 describe reaction injection molding processes for the production of polyurethane(urea) elastomers. As used herein, the term "polyurethanes" includes polyurethanes, polyureas, and polyurethane polyureas.

Although the process described in the '543 patent has met with commercial success, the industry has searched for ways to improve the overall properties of the molded parts.

#### DESCRIPTION OF THE INVENTION

The present invention is directed to novel isocyanates and the use thereof in a RIM process. More particularly, the invention is directed to a liquid, room temperature stable, polyisocyanate having an isocyanate group content of from 6 to 31% by weight and being prepared by reacting:

- a) an isocyanate mixture comprising:

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- 1) from 65 to 90% by weight of 4,4'-diphenylmethane diisocyanate,
- 2) from 10 to 35% by weight of 2,4'-diphenylmethane diisocyanate, and
- 5 3) no more than 2% by weight of 2,2'-diphenylmethane diisocyanate, the percents of components a)1), a)2) and a)3) totalling 100%, and
- b) a mixture comprising:
  - 1) one or more organic compounds having molecular weights  
10 of from 400 to 6000 and containing from 2 to 8 groups selected from the group consisting of hydroxyl groups, primary amine groups and secondary amine groups, and
  - 2) one or more organic diols having molecular weights of from 60 to 200, excluding tripropylene glycol, the weight ratio of  
15 b)1) to b)2) being from 150:1 to 5:1.

The invention is also directed to a process for the production of a molding by reacting a reaction mixture comprising: a) a polyisocyanate, b) one or more relatively high molecular weight active hydrogen group containing compounds, and c) one or more relatively low molecular  
20 weight chain extenders, said reaction mixture being processed as a one-shot system by the RIM process at an isocyanate index of from about 70 to about 130. The improvement resides in using as the above-identified novel polyisocyanate.

The use of the specific isocyanate allows for the production of  
25 molded products having improved tear strength, improved flexural modulus, improved impact resistance, and improved tensile strength.

The isocyanate used herein has an isocyanate group content of from 6 to 31% by weight, preferably from 10 to 29% by weight, and most

preferably from 13 to 23% by weight and is the reaction product of:

a) an isocyanate mixture comprising:

- 1) from 65 to 90% by weight (preferably from 70 to 90% by weight and most preferably from 80 to 90% by weight), of 4,4'-diphenylmethane diisocyanate,
- 2) from 10 to 35% by weight (preferably from 10 to 30% by weight and most preferably from 10 to 20% by weight) of 2,4'-diphenylmethane diisocyanate, and
- 3) no more than 2% by weight (preferably only a trace )of 2,2'-diphenylmethane diisocyanate, the percents of components a)1), a)2) and a)3) totalling 100%, and

b) a mixture comprising:

- 1) one or more organic compounds having molecular weights of from 400 to 6000 (preferably from 500 to 5000 and most preferably from 1000 to 4800) and containing from 2 to 8 groups (preferably from 2 to 6 and most preferably from 2 to 4) selected from the group consisting of hydroxyl groups, primary amine groups and secondary amine groups, and
- 2) one or more organic diols having molecular weights of from 60 to 200, excluding tripropylene glycol, the weight ratio of b)1) to b)2) being from 150:1 to 5:1 (preferably from 120:1 to 10:1 and most preferably from 50:1 to 10:1).

The individual components of the isocyanate mixture are known in the art. As is known, polymethylene poly(phenyl isocyanates) are prepared by aniline-formaldehyde condensation followed by phosgenation. As is known in the art, the relatively pure diisocyanate isomers are obtained by distilling the resultant polymethylene poly(phenyl isocyanate). Upon distillation, the distillate consists largely of the 4,4'-

isomer with a smaller amount of the 2,4'-isomer, and with relatively small or trace amounts of the 2,2'-isomer. By further refining techniques known in the art, it is possible to obtain isomer mixtures having varied ratios of the 4,4'- and 2,4'-isomers. Known processes for preparing such isocyanates are described, e.g., in U.S. Patents 2,683,730, 2,950,263, 3,012,008, 3,344,162 and 3,362,979.

The isocyanate reactive materials used to produce the isocyanate products of the present invention are known. One necessary component is the 400 to 6000 molecular weight compound. Examples of suitable high molecular weight compounds include the polyesters, polyethers, polythio-ethers, polyacetals and polycarbonates containing at least 2, preferably 2 to 8 and most preferably 2 to 4 isocyanate-reactive groups of the type known for the production of polyurethanes.

The polyethers suitable for use in accordance with the invention are known and may be obtained, for example, by polymerizing epoxides such as ethylene oxide, propylene oxide, butylene oxide, tetrahydrofuran, styrene oxide, or epichlorohydrin in the presence of  $\text{BF}_3$  or by chemically adding these epoxides, preferably ethylene oxide and propylene oxide, in admixture or successively to components containing reactive hydrogen atoms such as water, alcohols, or amines. Examples of alcohols and amines include the low molecular weight chain extenders set forth hereinafter, 4,4'-dihydroxydiphenylpropane, sucrose, aniline, ammonia, ethanolamine, and ethylene diamine. It is preferred to use polyethers which contain substantial amounts of primary hydroxyl groups in terminal positions (up to 90% by weight, based on all of the terminal hydroxyl groups present in the polyether). Polyethers modified by vinyl polymers, of the type formed, for example, by polymerizing styrene or acrylonitrile in the presence of polyether (U.S. Patents 3,383,351, 3,304,273, 3,523,093,

and 3,110,695; and German Patent 1,152,536), are also suitable, as are polybutadienes containing OH groups.

In addition, polyether polyols which contain high molecular weight polyadducts or polycondensates in finely dispersed form or in solution may be used. Such modified polyether polyols are obtained when polyaddition reactions (e.g., reactions between polyisocyanates and amino functional compounds) or polycondensation reactions (e.g., between formaldehyde and phenols and/or amines) are directly carried out in situ in the polyether polyols.

Suitable examples of polyesters include the reaction products of polyhydric, preferably dihydric alcohols (optionally in the presence of trihydric alcohols), with polyvalent (preferably divalent) carboxylic acids. Instead of using the free carboxylic acids, it is also possible to use corresponding polycarboxylic acid anhydrides or corresponding polycarboxylic acid esters of lower alcohols or mixtures thereof for producing the polyesters. The polycarboxylic acids may be aliphatic, cycloaliphatic, aromatic, and/or heterocyclic and may be unsaturated or substituted (for example, by halogen atoms). The polycarboxylic acids and polyols used to prepare the polyesters are known and described, for example, in U.S. Patents 4,098,731 and 3,726,952. Suitable polythioethers, polyacetals, polycarbonates, and other polyhydroxyl compounds are also disclosed in the above-identified U.S. Patents. Finally, representatives of the many and varied compounds which may be used in accordance with the invention may be found for example in High Polymers, Volume XVI, "Polyurethanes, Chemistry and Technology," by Saunders and Frisch, Interscience Publishers, New York, London, Vol. I, 1962, pages 32-42 and 44-54, and Volume II, 1964, pages 5-6 and 198-199; and in

Kunststoff-Handbuch, Vol. VII, Vieweg-Höchtlen, Carl Hanser Verlag, Munich, 1966, pages 45-71.

Suitable aminopolyethers which may be used are those wherein at least about 30 and preferably about 60 to 100 equivalent percent of the isocyanate-reactive groups are primary and/or secondary (preferably primary) aromatically or aliphatically (preferably aromatically) bound amino groups and the remainder are primary and/or secondary aliphatically bound hydroxyl groups.

In these compounds, the terminal residues carrying the amino groups may also be attached to the polyether chain by urethane or ester groups. These "aminopolyethers" are prepared by known methods. For example, polyhydroxypolyethers such as polypropylene glycol ethers may be aminated by reaction with ammonia in the presence of Raney nickel and hydrogen (Belgian Patent 634,741). U.S. Patent 3,654,370 describes the production of polyoxyalkylene polyamines by reaction of the corresponding polyol with ammonia and hydrogen in the presence of a nickel, copper, or chromium catalyst. German Patent 1,193,671 describes the production of polyethers containing terminal amino groups by hydrogenation of cyanoethylated polyoxypropylene ethers. Other methods for the production of polyoxyalkylene (polyether) amines are described in U.S. Patents 3,155,728 and 3,236,895 and in French Patent 1,551,605. The production of polyethers containing terminal secondary amino groups is described, for example, in French Patent 1,466,708.

Polyhydroxypolyethers may be converted into the corresponding anthranilic acid esters by reaction with isatoic acid anhydride, as described, for example, in German Offenlegungsschriften 2,019,432 and 2,619,840 and in U.S. Patents 3,808,250, 3,975,428, and 4,016,143. Polyethers containing terminal aromatic amino groups are formed in this

way.

According to German Offenlegungsschrift 2,546,536 and U.S. Patent 3,865,791, relatively high molecular weight compounds containing terminal amino groups are obtained by reaction of NCO prepolymers based on polyhydroxypolyethers with enamines, aldimines, or ketimines containing hydroxyl groups and subsequent hydrolysis.

It is preferred to use amino polyethers obtained by hydrolysis of compounds containing terminal isocyanate groups, for example, in accordance with German Offenlegungsschrift 2,948,419 or U.S. Patent 4,515,923. In this process, polyethers most preferably containing 2 to 4 hydroxyl groups are allowed to react with polyisocyanates to form NCO prepolymers and, in a second step, the isocyanate groups are converted by hydrolysis into amino groups.

The aminopolyethers used in accordance with the invention are often mixtures of the compounds mentioned by way of example and (on a statistical average) most preferably contain 2 to 4 terminal isocyanate-reactive groups. In the process according to the invention, the aminopolyethers may be used in admixture with polyhydroxypolyethers free from amino groups.

The low molecular weight organic diols are also known in the art. Examples include ethylene glycol, 1,2- and 1,3-propanediol, 1,3- and 1,4- and 2,3-butanediol, 1,6-hexanediol, 1,10-decanediol, diethylene glycol, triethylene glycol, tetraethylene glycol, dipropylene glycol, glycerol, and trimethylolpropane, and specifically excludes tripropylene glycol.

The novel isocyanates herein are usually prepared by reacting the isocyanate with the active hydrogen group containing component at temperatures of from about 20° to about 115°C.

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Suitable reactants for use in the RIM process of the present invention include relatively high molecular weight compounds containing at least two isocyanate-reactive groups. These compounds generally have molecular weights of from 400 to about 10,000. The relatively low molecular weight chain extenders have molecular weights of from 62 to 399. Examples of suitable high molecular weight compounds include the polyesters, polyethers, polythioethers, polyacetals and polycarbonates containing at least 2, preferably 2 to 8 and most preferably 2 to 4 isocyanate-reactive groups of the type known for the production of polyurethanes.

The high molecular weight polyethers suitable for use in accordance with the invention are known and may be obtained, for example, by polymerizing epoxides such as ethylene oxide, propylene oxide, butylene oxide, tetrahydrofuran, styrene oxide, or epichlorohydrin in the presence of  $\text{BF}_3$  or by chemically adding these epoxides, preferably ethylene oxide and propylene oxide, in admixture or successively to components containing reactive hydrogen atoms such as water, alcohols, or amines. Examples of alcohols and amines include the low molecular weight chain extenders set forth hereinafter, 4,4'-dihydroxydiphenylpropane, sucrose, aniline, ammonia, ethanolamine, and ethylene diamine. It is preferred to use polyethers which contain substantial amounts of primary hydroxyl groups in terminal positions (up to 90% by weight, based on all of the terminal hydroxyl groups present in the polyether). Polyethers modified by vinyl polymers, of the type formed, for example, by polymerizing styrene or acrylonitrile in the presence of polyether (U.S. Patents 3,383,351, 3,304,273, 3,523,093, and 3,110,695; and German Patent 1,152,536), are also suitable, as are polybutadienes containing OH groups.

In addition, polyether polyols which contain high molecular weight polyadducts or polycondensates in finely dispersed form or in solution may be used. Such modified polyether polyols are obtained when polyaddition reactions (e.g., reactions between polyisocyanates and amino functional compounds) or polycondensation reactions (e.g., between formaldehyde and phenols and/or amines) are directly carried out in situ in the polyether polyols.

Suitable examples of high molecular weight polyesters include the reaction products of polyhydric, preferably dihydric alcohols (optionally in the presence of trihydric alcohols), with polyvalent (preferably divalent) carboxylic acids. Instead of using the free carboxylic acids, it is also possible to use corresponding polycarboxylic acid anhydrides or corresponding polycarboxylic acid esters of lower alcohols or mixtures thereof for producing the polyesters. The polycarboxylic acids may be aliphatic, cycloaliphatic, aromatic, and/or heterocyclic and may be unsaturated or substituted (for example, by halogen atoms). The polycarboxylic acids and polyols used to prepare the polyesters are known and described, for example, in U.S. Patents 4,098,731 and 3,726,952. Suitable polythioethers, polyacetals, polycarbonates, and other polyhydroxyl compounds are also disclosed in the above-identified U.S. Patents. Finally, representatives of the many and varied compounds which may be used in accordance with the invention may be found for example in High Polymers, Volume XVI, "Polyurethanes, Chemistry and Technology," by Saunders and Frisch, Interscience Publishers, New York, London, Vol. I, 1962, pages 32-42 and 44-54, and Volume II, 1964, pages 5-6 and 198-199; and in Kunststoff-Handbuch, Vol. VII, Vieweg-Höchtlen, Carl Hanser Verlag, Munich, 1966, pages 45-71.

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Suitable aminopolyethers which may be used in accordance with the present invention as high molecular weight compounds (the molecular weight always being the average molecular weight which may be calculated from the functionality and the content of isocyanate-reactive groups) are those wherein at least about 30 and preferably about 60 to 100 equivalent percent of the isocyanate-reactive groups are primary and/or secondary (preferably primary) aromatically or aliphatically (preferably aromatically) bound amino groups and the remainder are primary and/or secondary aliphatically bound hydroxyl groups.

10 In these compounds, the terminal residues carrying the amino groups may also be attached to the polyether chain by urethane or ester groups. These "aminopolyethers" are prepared by known methods. For example, polyhydroxypolyethers such as polypropylene glycol ethers may be aminated by reaction with ammonia in the presence of Raney nickel and hydrogen (Belgian Patent 634,741). U.S. Patent 3,654,370 describes the production of polyoxyalkylene polyamines by reaction of the corresponding polyol with ammonia and hydrogen in the presence of a nickel, copper, or chromium catalyst. German Patent 1,193,671 describes the production of polyethers containing terminal amino groups by hydrogenation of cyanoethylated polyoxypropylene ethers. Other methods for the production of polyoxyalkylene (polyether) amines are described in U.S. Patents 3,155,728 and 3,236,895 and in French Patent 1,551,605. The production of polyethers containing terminal secondary amino groups is described, for example, in French Patent 1,466,708.

25 Polyhydroxypolyethers of relatively high molecular weight may be converted into the corresponding anthranilic acid esters by reaction with isatoic acid anhydride, as described, for example, in German Offenlegungsschriften 2,019,432 and 2,619,840 and in U.S. Patents

3,808,250, 3,975,428, and 4,016,143. Polyethers containing terminal aromatic amino groups are formed in this way.

According to German Offenlegungsschrift 2,546,536 and U.S. Patent 3,865,791, relatively high molecular weight compounds containing terminal amino groups are obtained by reaction of NCO prepolymers based on polyhydroxypolyethers with enamines, aldimines, or ketimines containing hydroxyl groups and subsequent hydrolysis.

It is preferred to use amino polyethers obtained by hydrolysis of compounds containing terminal isocyanate groups, for example, in accordance with German Offenlegungsschrift 2,948,419 or U.S. Patent 4,515,923. In this process, polyethers most preferably containing 2 to 4 hydroxyl groups are allowed to react with polyisocyanates to form NCO prepolymers and, in a second step, the isocyanate groups are converted by hydrolysis into amino groups.

The aminopolyethers used in accordance with the invention are often mixtures of the compounds mentioned by way of example and (on a statistical average) most preferably contain 2 to 4 terminal isocyanate-reactive groups. In the process according to the invention, the aminopolyethers may be used in admixture with polyhydroxypolyethers free from amino groups.

In accordance with the present invention, the high molecular weight compounds are used in admixture with up to about 95% by weight (preferably up to about 50% by weight, more preferably about 8 to 30% by weight, and most preferably about 12 to 26% by weight), based on the total quantity of the high molecular weight compounds, of the low molecular weight chain extenders. Examples of suitable hydroxyl group-containing chain extenders include ethylene glycol, 1,2- and 1,3-propane-

diol, 1,3- and 1,4- and 2,3-butanediol, 1,6-hexanediol, 1,10- decanediol, diethylene glycol, triethylene glycol, tetraethylene glycol, dipropylene glycol, tripropylene glycol, glycerol, and trimethylolpropane.

Other suitable chain extenders include aromatic polyamines  
 5 (preferably diamines) having molecular weights of less than 400, especially the sterically hindered aromatic polyamines (preferably diamines) having molecular weights of less than 400, especially the sterically hindered aromatic diamines which contain at least one linear or branched alkyl substituent in the ortho-position to the first amino group  
 10 and at least one (preferably two) linear or branched alkyl substituents containing from 1 to 4 (preferably 1 to 3) carbon atoms in the ortho-position to a second amino group. These aromatic diamines include 1-methyl-3,5-diethyl-2,4-diaminobenzene, 1-methyl-3,5-diethyl-2,6-diaminobenzene, 1,3,5-trimethyl-2,4-diaminobenzene, 1,3,5-triethyl-2,4-diaminobenzene, 3,5,3',5'-tetraethyl-4,4'-diaminodiphenylmethane, 3,5,3',5'- tetra-  
 15 isopropyl-4,4'-diaminodiphenylmethane, 3,5-diethyl-3',5'- diisopropyl-4,4'-diaminodiphenylmethane, 3,3'-diethyl-5,5'- diisopropyl-4,4'-diaminodiphenylmethane, 1-methyl-2,6-diamino- 3-isopropylbenzene, and mixtures of the above diamines. Most preferred are mixtures of 1-  
 20 methyl-3,5-diethyl-2,4-diaminobenzene and 1-methyl-3,5-diethyl-2,6-diaminobenzene in a weight ratio between about 50:50 to 85:15 (preferably about 65:35 to 80:20).

In addition, aromatic polyamines may be used in admixture with the sterically hindered chain extenders and include, for example, 2,4- and  
 25 2,6-diaminotoluene, 2,4'- and/or 4,4'-diaminodiphenylmethane, 1,2- and 1,4-phenylenediamine, naphthalene-1,5-diamine and triphenylmethane-4,4',4''-triamine. The difunctional and polyfunctional aromatic amine compounds may also exclusively or partly contain secondary amino

groups such as 4,4'-di(methylamino)diphenylmethane or 1-methyl-2-methylamino-4-aminobenzene. Liquid mixtures of polyphenyl poly-methylene-polyamines, of the type obtained by condensing aniline with formaldehyde, are also suitable. Generally, the nonsterically hindered  
5 aromatic diamines and polyamines are too reactive to provide sufficient processing time in a RIM system. Accordingly, these diamines and polyamines should generally be used in combination with one or more of the previously mentioned sterically hindered diamines or hydroxyl group-containing chain extenders.

10 Other materials which can be included in the reaction mixture include any of the materials generally used in the RIM art. For example, rigid microspheres, which can be hollow microspheres (also known as microballoons or microbubbles) or solid microspheres can be included. When preparing low-density materials, for example, hollow spheres are  
15 generally preferred. However, regardless of whether the microspheres are hollow or solid, they should be heat resistant and essentially incompressible when subjected to elevated temperatures and pressure during the molding process. In a typical RIM process, compression strengths greater than about 12 MPa (preferably greater than 20 MPa)  
20 are generally suitable. With hollow microspheres, wall thickness is, of course, a selection factor.

Suitably rigid microspheres may be made of inorganic materials, such as glass, ceramic, and carbon, or rigid organic polymers, such as phenolic resins. Solid microspheres can be prepared by any of several  
25 methods known in the art. For example, solid microspheres can be prepared by softening irregularly shaped particles just enough for them to flow into spheres under the influence of surface tension, by quenching a melt in a cooler medium, or by carrying out polymerizations in well-stirred

suspensions at elevated temperature.

Hollow inorganic microspheres can be prepared by several known methods. For example, hollow glass spheres can be prepared by grinding and sizing soda-lime glass cullet to form particles that, in  
5 combination with blowing agents, are passed through a gas flame (ca. 1000°C) to soften the glass and generates gases that expand the particles. See U.S. Patent 3,365,315. Hollow glass spheres can also be prepared by spray-drying a sodium borosilicate solution containing a blowing agent to form a particulate material that is passed through a gas  
10 flame to form the spheres. See U.S. Patent 2,978,339. Ceramic microspheres can be obtained as both solid and hollow microspheres as a normal aluminosilicate by-product of burning coal. In general, hollow ceramic microspheres are heavier than similarly sized glass microspheres. Although inorganic microspheres can be treated with a silane  
15 or titanate coupling agent to enhance adhesion with the matrix urethane polymer, the untreated particles generally exhibit sufficient adhesion to the polymer, making such treatments unnecessary.

Commercially available hollow inorganic microspheres include ceramic Z-Light Spheres\* and glass Scotchlite\* K46 Glass Bubbles from  
20 3M Company. See also, J.F. Plummer, "Microspheres" in Encyclopedia of Polymer Science and Technology, Vol. 9 (John Wiley & Sons, Inc., 1987), page 788.

Solid microspheres of organic polymers can be prepared using aqueous dispersions of suitable film-forming thermoset or thermoplastic  
25 materials. In the presence of a blowing agent, this method gives hollow microspheres.

It is typical of available rigid microspheres that a given sample contains a range of sizes. Suitable microspheres for the present  
\*trade-mark

invention typically have a diameter of between about 1 and about 350  $\mu\text{m}$  (preferably 10 to 210  $\mu\text{m}$ ). The specific size range, however, is often dependent on the selection of particular injection equipment and operating parameters (for example, nozzle diameter).

5           Low density (especially hollow) microspheres are preferred, with those having densities ranging from 0.05 to 2.5 g/cc being particularly preferred.

10           The rigid microspheres can be added to either the isocyanate component or the isocyanate-reactive component, although addition to isocyanate-reactive component is preferred. When used, the microspheres are added in amounts such that the final products have a total microsphere content of from about 0.5 to about 40% (preferably 2 to 10%) by weight. Products having density reductions in the range from 10 to 30% are readily obtained.

15           Although less preferred, it is also possible to include known compressible expanded microspheres, such as those described in U.S. Patents 4,829,094, 4,843,104, 4,902,722 and 4,959,395, but the amount of such microspheres should not exceed 50% by weight of the amount of the rigid microspheres. Commercially available compressible microspheres include Dualite\* M-6017-AE, Dualite M-6001-AE, and Dualite M-6029-AE, all available from Pierce & Stevens Corporation, and Expancel\*available from Nobel Industries. These commercially available compressible microspheres are expanded, hollow microspheres consisting of a thin shell of a vinylidene chloride, polypropylene, or 20 acrylonitrile copolymer. The interior of the Dualite and Expancel microspheres contains a volatile liquid, such as a low-boiling hydrocarbon (which is pentane for Dualite microspheres and isobutane for Expancel microspheres), which is used to expand the microsphere and remains

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inside the shell thereafter. An organic or inorganic material that decomposes upon only moderate heating will also serve to expand the microsphere, with the decomposition products remaining in the shell thereafter. Also present on the outside of Dualite microspheres is a  
5 rough coating of calcium carbonate dust.

In one preferred embodiment of the invention, which is particularly suitable for preparing low-density products, an inert gas is introduced into one or more of the reactive components (preferably into component (b)) using techniques known in the art. As used herein, the term "inert gas"  
10 refers to gaseous materials that are essentially unreactive under the conditions used in the process of the invention. Examples of suitable inert gases include air, nitrogen, argon, carbon dioxide, or mixtures thereof.

When preparing the preferred low density products, the inert gas is  
15 introduced in sufficient quantity to give products having a densities of from 0.75 g/cc to 1.1 g/cc. The inert gas is preferably introduced using commercial equipment, such as Diffuser Stone-KIMEX\* mixers and venturi type mixers. The presently preferred device is a Hennecke Aeromat-GU\* which is described in Hennecke Trade Bulletin # 41 and in a 1991 article  
20 entitled "Consistent Distribution of Finely Dispersed Gases in Polyol Streams", Proksa et al, Polyurethanes World Congress 1991. Sufficient inert gas is customarily introduced into the system in an amount in excess of the amount necessary to saturate the particular component at a feed tank pressure of from about 0.21 to about 0.35 N/mm<sup>2</sup>. As is  
25 known in the art, material flows from the feed tank through a transfer pump (which increases the pressure of the particular component) through a metering pump to the mixhead. Discharge pressures of the transfer pump are generally in the range of 0.35 to 0.7 N/mm<sup>2</sup>, while discharge

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pressures of the metering pump are generally in the range of 14 to 21 N/mm<sup>2</sup>. The amount of the gas in the system is generally monitored using commercial measuring equipment which responds to changes in specific gravity of the liquid components. One such device is the  
5 Dynatrol (manufactured by Automation Products), which permits the effective control of the gas content by monitoring any changes in the specific gravity of the liquid component.

When preparing low density products, factors that are important to achieving high quality low density product include enhanced flow  
10 characteristics and reduced nucleation density of the isocyanate-reactive component. Good flow properties are important because relatively smaller quantities of reactive materials are required for low density products. Reduced nucleation density is directly related to an increased amount of inert gas dissolved or dispersed in the isocyanate-reactive  
15 component and ultimately to a lower density product. The use of rigid microspheres according to the present invention has been found to be particularly useful in enhancing both the flow characteristics and the nucleation density of the isocyanate-reactive component, as well as reducing the time required to achieve a given nucleation density. As a  
20 result, a significant reduction in density for the molded parts is achieved while at the same time improving demold characteristics (such as mold release, green strength, and hot tear strength) without adversely affecting physical properties. In fact, impact resistance is consistently improved. The use of hollow rather than solid microspheres provides an even  
25 further reduction in density, while still providing improved physical properties and demold characteristics, and is thus particularly preferred.

Reinforcing fillers, which allow reduced contraction of the molded product upon cooling, as well as adjustment of tensile modulus and flex

modulus, can also be used and are well known in the art. Suitable inorganic fillers include glass in the form of fibers or flakes, mica, wollastonite, carbon black, talc, calcium carbonate, and carbon fibers. Organic fillers, although less preferred, are also suitable.

5           Other additives which may be used in the present invention include catalysts, especially tin(II) salts of carboxylic acids, dialkyltin salts of carboxylic acids, dialkyltin mercaptides, dialkyltin dithioesters, and tertiary amines. Preferred among these catalysts are dibutyltin dilaurate and 1,4-diazabicyclo[2,2,2]octane (triethylene diamine), especially  
10       mixtures of these catalysts. The catalysts are generally used in amounts of about 0.01 to 10% (preferably about 0.05 to 2%), based on the weight of the high molecular weight component.

          It is also possible to use surface-active additives such as emulsifiers and foam stabilizers. Examples include siloxanes, N-stearyl-  
15       N',N'-bis-hydroxyethyl urea, oleyl polyoxyethylene amide, stearyl diethanol amide, isostearyl diethanolamide, polyoxyethylene glycol monoleate, a pentaerythritol/adipic acid/oleic acid ester, a hydroxyethyl imidazole derivative of oleic acid, N-stearyl propylene diamine, and the sodium salts of castor oil sulfonates or of fatty acids. Alkali metal or  
20       ammonium salts of sulfonic acid, such as dodecylbenzenesulfonic acid or dinaphthylmethanesulfonic acid, and fatty acids may also be used as surface-active additives. Particularly suitable surface-active compounds include polyether siloxanes of the type generally known for use in the polyurethane art, such as water-soluble polyether siloxanes. The  
25       structure of these siloxanes is generally such that a copolymer of ethylene oxide and propylene oxide is attached to a polydimethylsiloxane functionality. Methods of manufacturing preferred siloxanes are described in U.S. Patent 4,906,721.

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It is also possible to use mold release agents, which are compounds that are added to the reactive components of the isocyanate addition reaction, usually the isocyanate-reactive component, to assist in the removal of a polyurethane product from a mold. Suitable mold release agents for the present invention include those based at least in part on fatty acid esters (e.g., U.S. Patents 3,726,952, 3,925,527, 4,058,492, 4,098,731, 4,201,847, 4,254,228, 4,868,224, and 4,954,537 and British Patent 1,365,215); metal and/or amine salts of carboxylic acids, amido carboxylic acids, phosphorus-containing acids, or boron-containing acids (e.g., U.S. Patents 4,519,965, 4,581,386, 4,585,803, 4,876,019, 4,895,879, and 5,135,962); polysiloxanes (e.g., U.S. Patent 4,504,313); amidines (e.g., U.S. Patents 4,764,540, 4,789,688, and 4,847,307); resins prepared by the reaction of isocyanate prepolymers and a polyamine-polyimine component (e.g., U.S. Patent 5,198,508); neutralized esters prepared from certain amine-started tetrahydroxy compounds described in U.S. Patent 5,208,268; and aliphatic polyalkylene and polyalkadienes. Preferred mold release agents contain zinc stearate.

In addition to the reinforcement fillers, catalysts, surface-active agents, and mold release agents mentioned above, other additives which may be used in the molding compositions of the present invention include known fillers of other types, blowing agents, cell regulators, flame retarding agents, plasticizers, and dyes of the types generally known in the art.

The compositions according to the present invention are especially suited for processing by the RIM process. In general, two separate streams are intimately mixed and subsequently injected into a suitable

mold, although it is possible to use more than two streams. The first stream contains the polyisocyanate component, whereas the second stream contains the isocyanate-reactive component, chain extender, any internal mold release agent, and any other additives which are to be  
5 included.

The quantity of polyisocyanate used in the process according to the present invention is preferably calculated so that the reaction mixture has an isocyanate index of from 70 to 130 (preferably from 90 to 110). By "isocyanate index" is meant the quotient of the number of isocyanate  
10 groups and number of groups which are reactive with isocyanates, multiplied by 100.

The known RIM process is used for carrying out the process according to the present invention. In general, the components may be mixed simultaneously, or the non-reactive components may be pre-mixed  
15 and then mixed with the reactive components. A starting temperature of from 10° to 70°C (preferably from 30° to 50°C) is generally chosen for the mixture introduced into the mold. The temperature of the mold itself is generally from 40° to 100°C (preferably from 50° to 70°C). After completion of the reaction and molding process, the resultant product is  
20 removed from the mold.

The process of the invention is characterized by improved mold release, which permits less frequent use of mold release agents (particularly external mold release agents) and less frequent cleaning of product residues and/or fragments from the molds or aftermixers.

25 The moldings obtainable by the process according to the present invention are particularly suitable for the manufacture of a variety of polyurethane products. For example, in a preferred embodiment of the invention, low density products such as flexible car bumpers and car

5

percentages by weight, respectively.

10

In the examples which follow, the following materials were used:

POLYOL A: a propylene glycol/propylene oxide adduct having a molecular weight of about 2000.

15

POLYOL C: a glycerine/propylene oxide/ethylene oxide adduct (containing the ethylene oxide as a 17% by weight termination) having a molecular weight of about 4800.

20

**POLYOL E:** a propylene glycol/propylene oxide adduct having a molecular weight of about 1000.

DPG: dipropylene glycol

PG: propylene glycol

25

MDI - X: Diphenylmethane diisocyanate containing less than 2% by weight of the 2,2'-isomer, X% of the 2,4'-isomer and the balance being the 4,4'-isomer.

T-5000\*: a polyoxypropylene triol based aliphatic polyamine with a molecular weight of 5000, available from Texaco Chemical Co. (Jeffamine T-5000)

5      D-2000 \*: a polyoxypropylene diol based aliphatic polyamine with a molecular weight of 2000, available from Texaco Chemical Co. (Jeffamine D-2000)

DETDA: an 80/20 mixture of 1-methyl-3,5-diethyl,2,4- and 2,6-phenyl diamine

ZN ST: zinc stearate

10      L-5304\*: a silicone surfactant available from Union Carbide Co.

Example 1 (comparative):

15      100 parts of MDI-15 were charged to a reactor and heated to 105°C. 62.9 parts of POLYOL A and 0.05 parts of benzoyl chloride were added to the reactor over a period of about 2 minutes. The mixture was held at 105°C for about 30 minutes and then cooled to room temperature. The resultant product, which had an isocyanate group content of 18.9% by weight, became turbid at room temperature and formed a small amount of solids.

Example 2

20      100 parts of MDI-15 were charged to a reactor and heated to 105°C. 55.7 parts of POLYOL A, 1.5 parts of XB and 0.05 parts of benzoyl chloride were added to the reactor over a period of about 2 minutes. The mixture was held at 105°C for about 30 minutes and then cooled to room temperature. The resultant product, which had an isocyanate group content of 18.7% by weight, was clear and solid-free after 8 months storage at room temperature.

Example 3 (comparative)

100 parts of MDI-20 were charged to a reactor and heated to

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105°C. 34 parts of POLYOL A and 0.05 parts of benzoyl chloride were added to the reactor over a period of about 1 minute. The mixture was held at 105°C for about 25 minutes and then cooled to room temperature. The resultant product, which had an isocyanate group content of 24.3% by weight, became turbid at room temperature and formed a large amount of solids.

#### Example 4

100 parts of MDI-20 were charged to a reactor and heated to 105°C. 27.9 parts of POLYOL A, 1.5 parts of XB and 0.05 parts of benzoyl chloride were added to the reactor over a period of about 1 minute. The mixture was held at 105°C for about 25 minutes and then cooled to room temperature. The resultant product, which had an isocyanate group content of 23.6% by weight, was clear and solid-free after 8 months storage at room temperature.

#### Example 5 (comparative)

100 parts of MDI-25 were charged to a reactor and heated to 105°C. 25.2 parts of POLYOL A and 0.06 parts of benzoyl chloride were added to the reactor over a period of about 1 minute. The mixture was held at 105°C for about 30 minutes and then cooled to room temperature. The resultant product, which had an isocyanate group content of 26.2% by weight, became turbid at room temperature and formed a small amount of solids.

#### Example 6

100 parts of MDI-25 were charged to a reactor and heated to 105°C. 19.3 parts of POLYOL A, 1.5 parts of XB and 0.05 parts of benzoyl chloride were added to the reactor over a period of about 1 minute. The mixture was held at 105°C for about 30 minutes and then cooled to room temperature. The resultant product, which had an

isocyanate group content of 25.5% by weight, was clear and solid-free after 8 months storage at room temperature.

Example 7 (comparative)

100 parts of MDI-30 were charged to a reactor and heated to  
5 105°C. 34 parts of POLYOL A and 0.05 parts of benzoyl chloride were added to the reactor over a period of about 1 minute. The mixture was held at 105°C for about 30 minutes and then cooled to room temperature. The resultant product, which had an isocyanate group content of 23.8% by weight, formed a small amount of solids when stored  
10 at room temperature.

Example 8

100 parts of MDI-30 were charged to a reactor and heated to  
105°C. 27.9 parts of POLYOL A, 1.5 parts of XB and 0.05 parts of benzoyl chloride were added to the reactor over a period of about 1  
15 minute. The mixture was held at 105°C for about 25 minutes and then cooled to room temperature. The resultant product, which had an isocyanate group content of 23.8% by weight, was clear and solid-free after 8 months storage at room temperature.

Example 9 (comparative)

20 100 parts of MDI-35 were charged to a reactor and heated to 105°C. 13.9 parts of POLYOL A and 0.06 parts of benzoyl chloride were added to the reactor over a period of about 1 minute. The mixture was held at 105°C for about 25 minutes and then cooled to room temperature. The resultant product, which had an isocyanate group  
25 content of 29.1% by weight, formed a small amount of solids when stored at room temperature.

Example 10

100 parts of MDI-35 were charged to a reactor and heated to 105°C. 8.4 parts of POLYOL A, 1.5 parts of XB and 0.05 parts of benzoyl chloride were added to the reactor over a period of about 1 minute. The mixture was held at 105°C for about 25 minutes and then cooled to room temperature. The resultant product, which had an isocyanate group content of 28.8% by weight, was clear and solid-free after 8 months storage at room temperature.

Example 11 (comparative)

100 parts of MDI-2 were charged to a reactor and heated to 60°C. 66.6 parts of POLYOL B, 1.5 parts of XB and 0.06 parts of benzoyl chloride were added to the reactor over a period of about 1 minute. The mixture was held at 60°C for about 2 hours and then cooled to room temperature. The resultant product, which had an isocyanate group content of 17.6% by weight, became turbid at room temperature and formed a large amount of solids.

Example 12

The procedure of Example 11 was repeated except that MDI-10 was substituted for MDI-2. The resultant product, which had an isocyanate group content of 17.4% by weight, was clear and solid-free after 10 months storage at room temperature.

Examples 13 through 26

Examples 13 through 19 used the exact procedure of Example 2, while Examples 20 through 26 used the exact procedure of Example 11. In each example, the products produced were clear and solid-free. The materials use and the % isocyanate group content of each product were as indicated in the following Table 1:

TABLE 1

| Example          | MDI-X<br>used | pbw<br>MDI-X | POLYOL<br>used | pbw<br>POLYOL | DIOL<br>used | pbw<br>DIOL | NCO content<br>% by wt. |
|------------------|---------------|--------------|----------------|---------------|--------------|-------------|-------------------------|
| 13               | MDI-10        | 100          | A              | 68.6          | DPG          | 1.5         | 17.5                    |
| 14               | MDI-10        | 100          | A              | 36.5          | XB           | 3.0         | 20.9                    |
| 15               | MDI-10        | 100          | D              | 57.9          | PG           | 1.5         | 16.9                    |
| 16               | MDI-10        | 100          | E              | 51.9          | PG           | 1.5         | 18.0                    |
| 17               | MDI-10        | 100          | B              | 77.8          | PG           | 1.5         | 16.1                    |
| 18               | MDI-10        | 100          | C              | 42.8          | PG           | 3.0         | 19.5                    |
| 19               | MDI-10        | 100          | C              | 174.8         | XB           | 1.5         | 10.0                    |
| 20               | MDI-10        | 100          | A              | 66.6          | XB           | 1.5         | 17.8                    |
| 21               | MDI-10        | 100          | A              | 65.3          | PG           | 1.5         | 17.8                    |
| 22               | MDI-10        | 100          | E              | 28.2          | XB           | 1.5         | 22.7                    |
| 23 <sup>1)</sup> | MDI-10        | 100          | E              | 52.8          | XB           | 1.5         | 18.2                    |
| 24               | MDI-15        | 100          | C              | 45.0          | XB           | 3.0         | 19.7                    |
| 25               | MDI-20        | 100          | C              | 45.0          | XB           | 3.0         | 20.1                    |
| 26               | MDI-20        | 100          | C              | 42.8          | PG           | 3.0         | 20.1                    |

<sup>1)</sup> no benzoyl was added.

5 Example 27

100 parts of MDI-20 were charged to a reactor and the stirred isocyanate was heated to 60°C. 61 parts of POLYOL C and 3 parts of PG were added to the isocyanate with stirring over a period of about 2 minutes. The mixture was held at 60°C for about two hours and then  
10 cooled to room temperature. The resultant product, which had an isocyanate group content of 17.5%, remained clear and solid-free at room temperature.

Example 28 (comparative)

100 parts of MDI-20 were charged to a reactor and the stirred  
15 isocyanate was heated to 60°C. 80 parts of POLYOL C were added to the isocyanate with stirring over a period of about 2 minutes. The mixture was held at 60°C for about two hours and then cooled to room temperature. The resultant product, which had an isocyanate group content of 17.5%, became turbid with solids at room temperature. This  
20 material was warmed to about 50°C with stirring before being used in a RIM example.

RIM Example 1

A polyol blend was prepared by blending and thoroughly mixing 50.49 parts by weight (pbw) T-5000, 22.93 pbw D-2000, 22 pbw DETDA,  
25 1.08 pbw zinc stearate and 0.5 pbw L-5304. The blend was put into the B-side of a Hennecke RIMDOMAT\* RIM machine and the prepolymer of Example 27 was loaded into the A-side. The RIMDOMAT was equipped with a Hennecke MQ8\* Mixhead. The raw materials were heated to 45°C. The materials were injected in a 100/76.13 weight ratio of B side to A  
30 side at an injection pressure of 200 bar and an injection rate of 200 grams/sec. The material was injected into a flat plaque mold of 3 x 200 x 300 mm heated to 65 degrees Centigrade and sprayed with

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Chemtrend 2006 mold release spray. After a 30 second dwell time, the parts were removed from the mold. The parts were then postcured for 2 hours at 120°C and physical properties determined in accordance with the following ASTM standards:

|    |                                     |             |
|----|-------------------------------------|-------------|
| 5  | Room temperature flexural modulus - | ASTM D-790  |
|    | Elongation at break -               | ASTM D-412  |
|    | Tensile strength -                  | ASTM D-412  |
|    | Tear, die C -                       | ASTM D-624  |
|    | Notched Izod impact -               | ASTM D-256  |
| 10 | Heat sag, 4"/325°F -                | ASTM D-3769 |

The properties were as reported in TABLE 2.

#### RIM Examples 2-8

RIM Example 1 was repeated in an identical manner using the formulations noted in TABLES 2 and 3. The results were as set forth in

15 TABLES 2 and 3.

TABLE 2

|    | RIM Example                                  | 1      | 2      | 3      | 4      |
|----|----------------------------------------------|--------|--------|--------|--------|
| 5  | Polyol Components                            |        |        |        |        |
|    | T-5000                                       | 53.49  | 52.09  | 50.69  | 49.29  |
|    | D-2000                                       | 22.93  | 22.33  | 21.73  | 21.13  |
|    | DETDA                                        | 22     | 24     | 26     | 28     |
|    | ZN ST                                        | 1.08   | 1.08   | 1.08   | 1.08   |
|    | L-5304                                       | 0.5    | 0.5    | 0.5    | 0.5    |
| 10 | Isocyanate from Example #                    | 28     | 28     | 28     | 28     |
|    | NCO, wt. %                                   | 17.50  | 17.50  | 17.50  | 17.50  |
| 15 | Isocyanate index                             | 105    | 105    | 105    | 105    |
|    | Processing                                   |        |        |        |        |
| 20 | Ratio 100 pbw isocyanate to pbw polyol blend | 76.13  | 81.42  | 86.71  | 92     |
|    | Mold Temp, °C                                | 65     | 65     | 65     | 65     |
|    | Polyol Temp, °C                              | 40     | 40     | 40     | 40     |
| 25 | Iso. Temp, °C                                | 40     | 40     | 40     | 40     |
|    | Demold time, seconds                         | 30     | 30     | 30     | 30     |
| 30 | Physical Properties                          |        |        |        |        |
|    | Flex Mod., psi                               | 27,750 | 35,768 | 39,872 | 44,996 |
|    | Elongation %                                 | 291    | 274    | 317    | 276    |
| 35 | Tensile Str., psi                            | 3,874  | 3,863  | 4,361  | 4,081  |
|    | Die 'C' Tear, pli                            | 449    | 522    | 544    | 547    |
|    | Notched Izod, ft-lb/in                       | 6.9    | 8.2    | 8.2    | 8.5    |
| 40 | Ht Sag 4"/325°F, mm                          | 21.5   | 17.3   | 13.3   | 11.2   |

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TABLE 2

|    | RIM Example                                                   | 5      | 6      | 7      | 8      |
|----|---------------------------------------------------------------|--------|--------|--------|--------|
|    | Polyol Components                                             |        |        |        |        |
| 5  | T-5000                                                        | 53.49  | 52.09  | 50.69  | 49.29  |
|    | D-2000                                                        | 22.93  | 22.33  | 21.73  | 21.13  |
|    | DETDA                                                         | 22     | 24     | 26     | 28     |
|    | ZN ST                                                         | 1.08   | 1.08   | 1.08   | 1.08   |
|    | L-5304                                                        | 0.5    | 0.5    | 0.5    | 0.5    |
| 10 | Isocyanate<br>from example #                                  | 27     | 27     | 27     | 27     |
|    | NCO, wt. %                                                    | 17.50  | 17.50  | 17.50  | 17.50  |
| 15 | Isocyanate index                                              | 105    | 105    | 105    | 105    |
|    | Processing<br>Ratio 100 pbw isocyanate<br>to pbw polyol blend | 76.13  | 81.42  | 86.71  | 92     |
| 20 | Mold Temp, °C                                                 | 65     | 65     | 65     | 65     |
|    | Polyol Temp, °C                                               | 40     | 40     | 40     | 40     |
| 25 | Iso. Temp, °C                                                 | 40     | 40     | 40     | 40     |
|    | Demold time, seconds                                          | 30     | 30     | 30     | 30     |
| 30 | Physical Properties<br>Flex Mod., psi                         | 28,944 | 41,475 | 48,588 | 56,504 |
|    | Elongation, %                                                 | 268    | 303    | 283    | 278    |
| 35 | Tensile Str., psi                                             | 3,660  | 4,520  | 4,585  | 4,771  |
|    | Die 'C' Tear, pli                                             | 467    | 554    | 573    | 639    |
|    | Notched Izod,<br>ft-lb/in                                     | 6.5    | 9.5    | 10.3   | 11.4   |
| 40 | Ht Sag 4"/325° F, mm                                          | 18.5   | 16     | 15     | 13.2   |

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The two tables can be directly compared, i.e., Example 1 can be compared to Example 5, Example 2 with Example 6, Example 3 with Example 7 and Example 4 with Example 8. Upon comparison, the flexural modulus, tensile strength, tear strength and notched izod are all  
5 markedly improved while the remaining properties (heat sag and elongation) are similar.

Although the invention has been described in detail in the foregoing for the purpose of illustration, it is to be understood that such detail is solely for that purpose and that variations can be made therein  
10 by those skilled in the art without departing from the spirit and scope of the invention except as it may be limited by the claims.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A liquid, room temperature polyisocyanate having an isocyanate group content of from 6 to 31% by weight, prepared by  
5 reacting:

a) a methylene-bis(phenyl isocyanate) comprising

- 1) from 65 to 90% by weight of the 4,4'-isomer,
- 2) from 10 to 35% by weight of the 2,4'-isomer, and
- 3) no more than 2% by weight of the 2,2'-isomer,

10 with the percents of components a)1), a)2), and a)3) totalling 100%,

and

b) a mixture comprising:

- 1) one or more organic compounds having molecular weights of from 400 to 6000 and containing from 2 to 8 groups selected  
15 from the group consisting of hydroxyl groups, primary amine groups and secondary amine groups, and
- 2) one or more organic diols having molecular weights of from 60 to 200, excluding tripropylene glycol, the weight ratio of component b)1) to b)2) being from 150:1 to 5:1.

20 2. The isocyanate of Claim 1, having an isocyanate group content of from 10 to 29% by weight, and wherein:

a) said isocyanate mixture comprises:

- 1) from 70 to 90% by weight of the 4,4'-isomer,
- 2) from 10 to 30% by weight of the 2,4'-isomer, and
- 25 3) no more than a trace of the 2,2'-isomer,

with the percents of components a)1), a)2), and a)3) totalling 100%,

and

b) component b)1) has a molecular weight of from 500 to 5000 and contains from 2 to 6 of said groups, the weight ratio of b)1) to b)2)  
30 being from 120:1 to 10:1.

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3. The isocyanate of Claim 2, having an isocyanate group content of from 13 to 23% by weight, and wherein:

a) said isocyanate mixture comprises:

- 1) from 80 to 90% by weight of the 4,4'-isomer,
  - 5 2) from 10 to 20% by weight of the 2,4'-isomer, and
  - 3) no more than a trace of the 2,2'-isomer,
- with the percents of components a)1), a)2), and a)3) totalling 100%,

and

- b) component b)1) has a molecular weight of from 1000 to 4800 and
- 10 contains from 2 to 4 of said groups, the weight ratio of b)1) to b)2) being from 50:1 to 10:1.

4. In a process for the production of a molding by reacting a reaction mixture comprising: a) a polyisocyanate, b) one or more relatively high molecular weight active hydrogen group containing compounds, and

15 c) one or more relatively low molecular weight chain extenders, said reaction mixture being processed as a one-shot system by the RIM process at an isocyanate index of from about 70 to about 130, the improvement wherein said polyisocyanate comprises the liquid polyisocyanate of Claim 1.