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(54) Title: PROCESS FOR PREPARING OPEN-CELLED LOW DENSITY RIGID POLYURETHANE FOAM

(57) Abstract: Method for the preparation of low density open celled water blown rigid polyurethane foams comprising the step of reacting a polyisocyanate component with a polyol composition containing a first polyol component comprising at least one polyoxyalkylene polyol having oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 60 mg KOH/g and an average oxyethylene content of less than 50 wt%; a second polyol component comprising at least one polyoxyalkylene polyol containing oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 135 mg KOH/g and an average oxyethylene content of at least 50 wt%, the amount of the first polyol being at least 70 wt% and the amount of the second polyol being at most 30 wt% and wherein said polyol composition does not comprise any polyol having a hydroxyl number of more than 150 mg KOH/g.



WO 2011/045147 A2

DESCRIPTION

PROCESS FOR PREPARING OPEN-CELLED LOW DENSITY RIGID
POLYURETHANE FOAM

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The present invention relates to a process for preparing open celled rigid polyurethane foam, to the polyurethane foams obtainable by this process and to the use of these polyurethane foams as heat insulating material.

10 In general, rigid polyurethane foams are well known for their excellent heat insulating properties. Particularly closed celled polyurethane foams are widely used as heat insulating material in e.g. pipings, storage tanks, buildings and refrigerators. Closed celled polyurethane foams used to be made with blowing agents based on chlorofluorocarbons (CFC's) of which CFC 11 (trichlorofluoromethane) was a frequently applied example. The heat insulating
15 properties were for a large part determined by the thermal conductivity of CFC gases, which filled the cells of the foam. However, due to the ozone depleting effect of CFC's their use has become subject to strict environmental regulations and hence is limited nowadays. Alternative blowing agents have been investigated and are actually used, but it is very difficult to find substitutes for CFC as blowing agent, which have equally low thermal
20 conductivity properties.

Although open celled rigid polyurethane foams have not such excellent heat insulating properties as closed celled rigid foams, their thermal conductivity is still sufficient to be useful as a heat insulating material. Furthermore, the dimensional stability at low foam density of
25 open celled foams is better than that of closed-celled foams. Open celled rigid polyurethane foams can be used in those rigid foam applications, which do not require any heat insulating properties, but which do require some structural support, for instance, use for automotive headliners or packaging.

30 Several methods have been proposed to prepare open celled rigid polyurethane foams. For instance, in EP 547515 a method for preparing open celled rigid polyurethane foams is disclosed, wherein a polymethylene polyphenylisocyanate prepolymer is reacted with a polyol at an NCO/OH equivalent ratio of 1.3 to 3.0 using water as the sole blowing agent in the

presence of a catalyst, a foam stabiliser and a cell opening agent. The cell opening agent suitably is a divalent metal salt of a fatty acid, such as calcium stearate, magnesium stearate, strontium stearate or calcium myristate. The obtained foam is used as a vacuum heat insulating material.

- 5 According to EP 567027 open celled rigid polyurethane foams are prepared by using water as a blowing agent in combination with a specific polyol mixture comprising two or three polyols having different hydroxyl values, said mixture having a hydroxyl value of 160 to 360 mg KOH/g.

Another method is described in EP 581191, where an open celled rigid polyurethane foam is
10 prepared by reacting a polyol with a prepolymer obtained by reacting polymethylene polyphenyl polyisocyanate with a monohydric alcohol using a CFC-substitute as blowing agent in the presence of a catalyst, a foam stabiliser and a cell opening agent. The cell opening agent suitably is a divalent metal salt of a fatty acid, such as calcium stearate.

According to EP 745627 open celled polyisocyanurate foams are prepared at an isocyanate
15 index of 1.5 to 6 using water as primary blowing agent wherein the polyol blend contains a prepolymer derived from a polyether polyol of average functionality 2 to 6, number average molecular weight 700 to 6000 and oxyethylene unit content less than 10 wt%.

US 2003/0065046 describes a process for the preparation of open celled rigid polyurethane
20 foams by reaction of a polyfunctional isocyanate-reactive composition with a polyisocyanate composition comprising a prepolymer based on a high molecular weight oxyethylene-containing polyol. The obtained foams are used as core material in evacuated insulation panels.

Although these methods are effective in producing open celled rigid polyurethane foams,
25 there is still room for improvement.

It would be beneficial if open celled rigid polyurethane foams could be provided having a very low density in combination with good mechanical and/or structural stability, as such low density foams are attractive for use in a wide variety of applications including the application
30 as heat insulating material. The low density is especially desired, because the low weight of the foam facilitates transportation and handling of e.g. insulation panels. Moreover, a lower density also means that less starting material is necessary to prepare the same volume of foam

as compared to the situation in which a higher density foam is to be prepared. Clearly this is advantageous from an economic perspective.

WO 99/66045 describes a process for preparing low density open celled rigid polyurethane foam from a polyol blend comprising a polyol component having an average hydroxyl value

of 150 to 850 mg KOH/g (a so-called rigid polyol component) and a polymer polyol. According to US 2005/0043423 a low density open celled polyurethane sprayed foam is provided using water as blowing agent and a specific polyol mixture.

It is an object of the invention to provide a process for preparing low density open celled rigid polyurethane foam useful as thermal insulation material that does not comprise any so-called rigid polyol component.

The present invention provides a method for the preparation of open celled rigid polyurethane foams from a reaction mixture comprising a polyisocyanate component (a), a polyol composition (b) and a blowing agent wherein the polyol composition (b) comprises (b1) a first polyol component comprising at least one polyoxyalkylene polyol having oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 60 mg KOH/g, preferably not more than 50 mg KOH/g and an average oxyethylene content of less than 50 % , preferably less than 40 % by weight based on the weight of total oxyalkylene units; (b2) a second polyol component comprising at least one polyoxyalkylene polyol containing oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 135 mg KOH/g, preferably not more than 130 mg KOH/g and an average oxyethylene content of at least 50 %, preferably at least 70 % by weight based on the weight of total oxyalkylene units, the amount of the first polyol being at least 70 wt%, preferably at least 80 wt% based on the total polyol composition and the amount of the second polyol being at most 30 wt%, preferably at most 20 wt% based on the total polyol composition, and wherein said polyol composition does not comprise any polyol having a hydroxyl number of more than 150 mg KOH/g.

In the context of the present application the following terms have the following meaning:

- a rigid polyurethane foam: a foam that uncrushed has its major glass transition temperature above 50°C, most preferably above 80°C (DMTA, ISO/DIS 6721-5)
- isocyanate index or NCO index: the ratio of NCO groups over isocyanate-reactive hydrogen atoms present in a formulation, given as a percentage
- 5 • nominal hydroxyl functionality: the functionality (number of hydroxyl groups per molecule) of the polyol composition on the assumption that this is the functionality (number of active hydrogen atoms per molecule) of the initiator(s) used in their preparation

10 Polyols (b1) which may be used include products obtained by the polymerisation of ethylene oxide and propylene oxide in the presence of polyfunctional initiators. Suitable initiator compounds contain a plurality of active hydrogen atoms and include water, butanediol, ethylene glycol, propylene glycol, diethylene glycol, triethylene glycol, dipropylene glycol, ethanolamine, diethanolamine, triethanolamine,
15 cyclohexanedimethanol, glycerol, trimethylpropane, 1,2,6-hexanetriol and pentaerythritol. Mixtures of initiators and/or cyclic oxides may be used. The polyoxyethylene-polyoxypropylene polyols are obtained by the simultaneous or sequential addition of ethylene and propylene oxides to initiators as fully described in the prior art. Random copolymers, block copolymers and combinations thereof may be used having the indicated
20 amount of oxyethylene groups; preferred ones are those having at least part and preferably all of the oxyethylene groups at the end of the polymer chain (capped or tipped). Mixtures of the said polyols may be used as well.

Most preferred are polyoxyethylene polyoxypropylene polyols having an average nominal functionality of 2 to 4 and most preferably of 3, an average hydroxyl equivalent weight of
25 1100 to 3700, a hydroxyl number of 15 to 50 mg KOH/g and an oxyethylene content of 5 to 35 % by weight, preferably 10 to 30 % by weight, preferably having the oxyethylene groups at the end of the polymer chains. Such polyols are commercially available. Examples are DALTOCEL F428 and DALTOCEL F435 ex Huntsman (DALTOCEL is a trademark of Huntsman International LLC).

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During the last years several methods have been described to prepare polyether polyols having a low level of unsaturation. The developments have made it possible to use polyether polyols at the higher end of the molecular weight range since much polyols can

now be prepared with an acceptable low level of unsaturation. According to the present invention polyols having a low level of unsaturation may be used as well.

Polyols (b2) which may be used include products obtained by the polymerisation of ethylene oxide and optionally propylene oxide in the presence of polyfunctional initiators. Suitable initiator compounds contain a plurality of active hydrogen atoms and include water, butanediol, ethylene glycol, propylene glycol, diethylene glycol, triethylene glycol, dipropylene glycol, ethanolamine, diethanolamine, triethanolamine, cyclohexane dimethanol, glycerol, trimethylolpropane, 1,2,6-hexanetriol and pentaerythritol. Mixtures of initiators and/or cyclic oxides may be used. The polyoxyethylene-polyoxypropylene polyols are obtained by the simultaneous or sequential addition of ethylene and propylene oxides to initiators as fully described in the prior art. Random copolymers, block copolymers and combinations thereof may be used having the indicated amount of oxyethylene groups. Mixtures of the said polyols may be used as well.

Preferred polyols (b2) are those having an average nominal functionality of 2 to 4, an average equivalent weight of 370 to 2250 and an hydroxyl number of not more than 60 mg KOH/g and especially those having an oxyethylene content of at least 70 wt%. Polyoxyethylene polyols (hence having an oxyethylene content of 100 %) are also included as suitable polyols (b2). Polyols (b2) are commercially available; examples are polyoxyethylene diols having an average molecular weight of 200, 600 and 1000, DALTOCEL F526, F444, F442 and F555 all ex Huntsman (DALTOCEL is a trademark of Huntsman International LLC) and G2005 ex Uniqema.

The polyol composition according to the present invention is very suitable for the preparation of open celled rigid polyurethane foams having excellent properties. Thus, the present invention also relates to a process for the preparation of open celled rigid polyurethane foams, which process comprises reacting a polyol composition as described hereinbefore with a polyisocyanate component in the presence of at least a catalyst, a foam stabilising agent and a blowing agent.

Polyisocyanates that may be used are those conventionally applied in the production of rigid polyurethane foams. Useful polyisocyanates should contain at least two isocyanate groups and include both aliphatic – usually alkylene – and aromatic di-, tri-, tetra- and

higher isocyanates known in the art to be suitably applied in the production of rigid polyurethane foams. Mixtures of two or more of such aliphatic and/or aromatic polyisocyanates may also be applied. Examples of suitable polyisocyanates include 2,4-toluene diisocyanate (2,4-TDI), 2,6-TDI, mixtures of 2,4-TDI and 2,6-TDI, 1,5-naphthene diisocyanate, 2,4-methoxyphenyl diisocyanate, 4,4'-diphenylmethane diisocyanate (4,4'-MDI), 4,4'-biphenylene diisocyanate, 3,3'-dimethoxy-4,4'-biphenylene diisocyanate, 3,3'-dimethyl-4,4'-biphenylene diisocyanate and 3,3'-dimethyl-4,4'-diphenylmethane diisocyanate, 4,4',4''-triphenylmethane triisocyanate, 2,4,6-toluene triisocyanate, 4,4'-dimethyl-2,2',5,5'-diphenylmethane tetraisocyanate, polymethylene polyphenylene polyisocyanate and mixtures of two or more of these. Polymeric MDI, a mixture of polyisocyanates with MDI as the main component, may also be used. For the purpose of the present invention it has been found particularly advantageous to use polymeric MDI.

The polyisocyanate preferably comprises methylene diphenylisocyanate and a polymethylene polyphenylene polyisocyanate. By using such a mixture cell opening and flowability of the reaction mixture is improved. The polymethylene polyphenylene polyisocyanate is preferably present in an amount of at least 70 wt%, more preferably at least 80 wt% based on the total weight of the polyisocyanate composition. The methylene diphenylisocyanate generally is a mixture of the 2,4'- and 4,4'-isomers, advantageously such isomers are present in a weight ratio 2,4'-MDI : 4,4'-MDI of from 10:90 to 50:50, preferably from 15:85 to 50:50.

The quantity of polyisocyanate component and polyol composition to be used in the reaction of the present invention should suitably be such that the isocyanate index is lower than 150 wt% and preferably has a value between 95 and 150 wt%, most suitably between 95 and 130 wt%.

Catalysts for the production of rigid polyurethane foams are known in the art and include many different compounds. For the purpose of the present invention suitable catalysts include tertiary amines, such as, for instance, bis(2,2'-dimethylamino)ethyl ether, trimethylamine, triethylamine, triethylenediamine, N-methylmorpholine, N-ethylmorpholine, diethylethanolamine, N-cocomorpholine, 1-methyl-4-dimethylaminoethylpiperazine, 3-methoxypropyldimethylamine, N,N,N'-trimethylisopropyl

propylenediamine, 3-diethylamino-propyldiethylamine, dimethylbenzylamine and dimethylethanolamine (DMEA). Tin-based catalysts may also be applied and include tin salts and dialkyl tin salts of carboxylic acids. Specific examples are dibutyltin dilaureate, stannous octoate, stannous oleate, stannous chloride, dibutyltin acetate, dibutyltin-di-2-ethyl hexonate and dibutyltin diacetate. Also trimerisation catalysts like potassium acetate may be applied. The catalyst is typically used in an amount of from 0.01 to 10 parts by weight per 100 parts of the reaction formulation containing the polyols.

Preferred catalysts for use in the present invention include potassium acetate, triethylenediamine and N,N,N'-trimethyl-N'-hydroxyethyl-bisaminoethylether or any combination thereof.

The foam stabiliser (or surfactant) generally used in the present process may be any polyurethane foam stabiliser useful in the production of rigid polyurethane foams. Organosilicone or organopolysiloxane surfactants are most conveniently applied as foam stabilisers in polyurethane production. Usually, such foam stabiliser is used in an amount of up to 5 parts by weight per 100 parts of polyol-containing reaction formulation.

Preferably a cell-opening agent as known in the art is used in the present invention, preferably in an amount of 1 to 5 pbw or even more preferably 1 to 3.5 pbw per 100 pbw of polyol-containing reaction formulation. Polyether siloxanes are particularly suitable silicone cell-opening surfactants. These compounds generally have a polydimethyl siloxane group attached to a copolymer of ethylene oxide and propylene oxide. Examples of useful cell-opening silicone surfactants include those sold as L-3801 and L-3802 from WITCO.

Another type of suitable cell-opening agents are non-silicone organic polymers as described in DE 4303809. Such a preferred cell-opening surfactant for use in the present invention is ORTEGOL 501, a polybutadiene/diisononyl phthalate ex Evonik.

A blowing agent is also present in the process according to the present invention. Suitable blowing agents include water, acetone, (liquid) carbon dioxide, halogenated hydrocarbons, aliphatic alkanes such as n-pentane and isopentane, and alicyclic alkanes such as cyclopentane and cyclohexane. It will be understood that these blowing agents may be used singly or in mixtures of two or more. For the purpose of the present invention, it has

been found particularly advantageous to use water as the sole blowing agent. The amount in which the water is used may vary between wide limits, but very good results have been achieved when using water in an amount of 2 to 16 parts by weight per 100 parts of polyol-containing reaction formulation, preferably more than 6 or even more than 8 or 10 pbw.

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In addition, other well known auxiliaries, such as flame retardants, antioxidants, colouring agents and fillers may also be used.

If desired, flame retardants may be incorporated in the foams. Among the flame retardants which may be employed are: pentabromodiphenyl oxide, dibromopropinol, tris(β -chloropropyl)phosphate, 2,2-bis(-bromoethyl) 1,3-propanediol, tetrakis(2-chloroethyl)ethylene diphosphate, tris(2,3-dibromopropyl)phosphate, tris(β -chloroethyl)phosphate, triethylphosphate, tris(1,2-dichloropropyl)phosphate, bis-(2-chloroethyl) 2-chloroethylphosphonate, dimethylmethylphosphonate, diethylethylphosphonate, molybdenum trioxide, ammonium molybdate, ammonium phosphate, pentabromodiphenyl oxide, tricresylphosphate, hexabromocyclododecane, red phosphorus, aluminum oxide hydrate, ammonium polyphosphate, expandable graphite, melamine and dibromoethyl dibromocyclohexane.

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Preferably a flame retardant is used in the process of the present invention in such an amount that the obtained foam attains a B3 fire resistance classification (according to standard DIN 4102-1).

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In a further aspect, the invention provides for a reaction system for producing an open celled rigid polyurethane foam comprising a polyisocyanate composition (a) and a formulation containing a polyol composition (b), a blowing agent and optionally other additives, wherein the polyol composition (b) comprises (b1) a first polyol component comprising at least one polyoxyalkylene polyol having oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 60 mg KOH/g, preferably not more than 50 mg KOH/g and an average oxyethylene content of less than 50 % by weight, preferably less than 40 % based on the weight of total oxyalkylene units; (b2) a second polyol component comprising at least one polyoxyalkylene polyol containing oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 135 mg KOH/g, preferably not

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more than 130 mg KOH/g and an average oxyethylene content of at least 50 % by weight, preferably at least 70 % by weight based on the weight of total oxyalkylene units, the amount of the first polyol being at least 70 wt%, preferably at least 80 wt% based on the total polyol composition and the amount of the second polyol being at most 30 wt%, preferably at most 20 wt% based on the total polyol composition, and wherein said polyol composition does not comprise any polyol having a hydroxyl number of more than 150 mg KOH/g.

In a further aspect the present invention relates to an open celled rigid polyurethane foam obtainable by the process described hereinbefore, which polyurethane foam generally has a core density measured according to standard ISO 845 of less than 20 kg/m^3 and a closed cell content (determined by measurement with AccuPyc™ 1330 pycnometer) of less than 50 %, preferably less than 10 %, most preferably less than 5 %. Preferred foams, which are obtainable by the present process, have densities of 12 to 16 kg/m^3 . These foams are dimensionally stable.

The thermal conductivity at 10°C of these foams measured according to standard ISO 8301 is generally above 33 mW/mK , usually about 37 mW/mK .

The foams according to the present invention are generally produced via lamination.

The present invention also relates to shaped articles comprising the open celled rigid polyurethane foam of the present invention as well as to heat insulating materials comprising this open celled rigid polyurethane foam in a laminate structure, for example, in cavity wall or in-between roof rafter insulation.

Heat insulating materials comprising the open celled rigid polyurethane foams of the present invention can easily compete both on cost and performance with thermal insulation materials based on extruded polystyrene (EPS) or mineral or glass wool. Compared to glass wool insulation the insulation using the presently claimed foams has the additional benefit of being fibre-free, not using any formaldehyde binder, of providing stiffer boards (compressive strength about 25 kPa) (and hence easier to install) and no sagging inside the cavity. Compared to EPS as thermal insulation material, boards made from the presently claimed foams have better fire resistance.

This invention also relates to a process for preparing a laminate article comprising a facing material having contiguous to it an open celled rigid polyurethane foam as described above. In such a process the above-described reaction ingredients are first brought together to give a polymerizing mixture which is then subsequently brought into contact with the facing material and permitted to terminate its polymerization reaction.

The selection of the facing material is in accordance with suitability for its intended end application and can be a plastic resin, a cellulose-based material, a lignocellulose-based material or a metal sheet or foil.

The various aspects of this invention are illustrated, but not limited by the following examples.

In these examples the following ingredients were used:

Polyol 1: a polyether polyol of OH value 35 mg KOH/g, functionality 3, molecular weight 4800 and oxyethylene content 17.2 wt%

Polyol 2: a polyether polyol of OH value 42 mg KOH/g, functionality 3, molecular weight 4000 and oxyethylene content 76 wt%

Catalyst 1: amine catalyst

Catalyst 2: metal salt catalyst

Cell opener: non-silicone cell opening agent

Fire retardant: phosphate fire retardant

Catalyst 3: amine catalyst

Iso 1: polymeric MDI

Iso 2: a polyisocyanate composition containing 88 wt% polymeric MDI and 12 wt% of an MDI isomer mixture of 2,4'- and 4,4'-MDI in a ratio of 17:83

EXAMPLE

Open celled rigid polyurethane foams were made on a laminator from the ingredients listed below in Table 1 and Table 2. Two separate runs were made with each formulation.

The following properties were measured on the obtained foams: core density measured according to standard ISO 845, closed cell content (CCC) measured with AccuPyc™ 1330

pycnometer, thermal conductivity (λ) measured according to standard ISO 8301, compressive strength in all 3 directions measured according to standard DIN 53421.

The results are also reported in Table 1 and Table 2.

Table 1

			Run 1	Run 2
Polyol 1	pbw	46.52		
Polyol 2	pbw	5.79		
Water	pbw	10.80		
Catalyst 1	pbw	0.72		
Catalyst 2	pbw	5.79		
Cell Opener	pbw	1.45		
Fire retardant	pbw	28.93		
Catalyst 3	pbw	1.50		
Iso 1	pbw	192.66		
Ratio I/P		1.9266		
Thickness	cm		15	8
Facing			Paper	Paper
Line speed	m/min		7	9
Output	g/s		295	225
Dwell Time	min		3.5	3
Core Density	kg/m ³		12.6	14.1
Lambda	mW/mK		36.6	36.6
Comp Strength Length	kPa		22	18.3
Comp Strength Width	kPa		15.2	22.2
Comp Strength Thickness	kPa		21.7	26.8

Table 2

			Run 1	Run 2
Polyol 1	pbw	45.9		
Polyol 2	pbw	5.7		
Water	pbw	10.67		
Catalyst 1	pbw	0.71		
Catalyst 2	pbw	5.70		
Cell Opener	pbw	1.43		
Fire retardant	pbw	28.52		
Catalyst 3	pbw	1.43		
Iso 2	pbw	190		
Ratio I/P		1.90		
Thickness	cm		15	8
Facing			Paper	Paper
Line speed	m/min		7	9
Output	g/s		295	225
Dwell Time	min		3.5	3
Core Density	kg/m ³		12.5	13.9
Lambda	mW/mK		36.8	37.0
Comp Strength Length	kPa		23	23.4
Comp Strength Width	kPa		15.7	16.5
Comp Strength Thickness	kPa		21.9	22.0

CLAIMS

1. Method for the preparation of open celled rigid polyurethane foams comprising the step of reacting a polyisocyanate composition (a) with a polyol composition (b) in the presence of a blowing agent characterised in that the polyol composition (b) comprises (b1) a first polyol component comprising at least one polyoxyalkylene polyol having oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 60 mg KOH/g, preferably not more than 50 mg KOH/g and an average oxyethylene content of less than 50 %, preferably less than 40 % by weight based on the weight of total oxyalkylene units; (b2) a second polyol component comprising at least one polyoxyalkylene polyol containing oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 135 mg KOH/g, preferably not more than 130 mg KOH/g and an average oxyethylene content of at least 50 % by weight, preferably at least 70 % by weight based on the weight of total oxyalkylene units, the amount of the first polyol being at least 70 wt%, preferably at least 80 wt% based on the total polyol composition and the amount of the second polyol being at most 30 wt%, preferably at most 20 wt% based on the total polyol composition, and wherein said polyol composition does not comprise any polyol having a hydroxyl number of more than 150 mg KOH/g.
2. Method according to claim 1 wherein polyol (b1) comprises a polyoxyethylene polyoxypropylene polyol having an average nominal functionality of 2 to 4 and most preferably of 3, an average hydroxyl equivalent weight of 1100 to 3700, a hydroxyl number of 15 to 50 mg KOH/g and an oxyethylene content of 5 to 35 % by weight, preferably 10 to 30 % by weight, preferably having the oxyethylene groups at the end of the polymer chains.
3. Method according to claim 1 or 2 wherein polyol (b2) comprises a polyoxyalkylene polyol having an average nominal functionality of 2 to 4, an average equivalent weight of 370 to 2250 and an hydroxyl number of not more than 60 mg KOH/g and especially those having an oxyethylene content of at least 70 wt%.
4. Method according to any one of the preceding claims wherein the polyisocyanate composition comprises methylene diphenylisocyanate and a polymethylene polyphenylene polyisocyanate wherein the amount of polymethylene polyphenylene polyisocyanate is preferably at least 70 wt% based on the total weight of the

polyisocyanate composition and wherein the methylene diphenylisocyanate is a mixture of the 2,4'- and 4,4'-isomers, with such isomers preferably being present in a weight ratio 2,4'-MDI : 4,4'-MDI of from 10:90 to 50:50, preferably from 15:85 to 50:50.

- 5 5. Method according to any one of the preceding claims wherein water is used as the sole blowing agent, preferably in an amount of 2 to 16 pbw per 100 pbw of reaction formulation containing the polyol composition.
6. Method according to any one of the preceding claims wherein the polyisocyanate composition and the polyol composition are reacted in such a quantity that the isocyanate
10 index is lower than 150 wt%.
7. Method according to any one of the preceding claims wherein the reaction is carried out in the presence of a cell-opening agent.
8. Reaction system for producing an open celled rigid polyurethane foam comprising a polyisocyanate composition (a) and a formulation containing a polyol composition (b),
15 a blowing agent and optionally other additives, wherein the polyol composition (b) comprises (b1) a first polyol component comprising at least one polyoxyalkylene polyol having oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 60 mg KOH/g, preferably not more than 50 mg KOH/g and an average oxyethylene content of less
20 than 50 % by weight, preferably less than 40 % based on the weight of total oxyalkylene units; (b2) a second polyol component comprising at least one polyoxyalkylene polyol containing oxyethylene residues, said component having an average nominal hydroxyl functionality of 2 to 4, an hydroxyl number of not more than 135 mg KOH/g, preferably not more than 130 mg KOH/g and an average
25 oxyethylene content of at least 50 % by weight, preferably at least 70 % by weight based on the weight of total oxyalkylene units, the amount of the first polyol being at least 70 wt%, preferably at least 80 wt% based on the total polyol composition and the amount of the second polyol being at most 30 wt%, preferably at most 20 wt% based on the total polyol composition, and wherein said polyol composition does not
30 comprise any polyol having a hydroxyl number of more than 150 mg KOH/g.
9. Open celled rigid polyurethane foam obtainable by the method as defined in any one of claims 1 to 7.

10. Open celled rigid polyurethane foam according to claim 9 having a core density of less than 20 kg/m^3 , a closed cell content of less than 50 % and a thermal conductivity at 10°C above 33 mW/mK .
11. Use of an open celled rigid polyurethane foams as defined in claim 9 or 10 as heat
5 insulating material.
12. Laminate article comprising a facing material having contiguous thereto an open celled rigid polyurethane foam as defined in claim 9 or 10.