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(54) Title: INSULATION BOARDS AND METHODS FOR THEIR MANUFACTURE

(57) **Abrégé/Abstract:**

A method for producing polyisocyanurate insulation foams, the method comprising contacting an A-side stream of reactants that includes an isocyanate with a B-side stream of reactants that include a polyol and a blowing agent, where the blowing agent includes isopentane and n-pentane in a substantial absence of cyclopentane.



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ABSTRACT OF THE DISCLOSURE

A method for producing polyisocyanurate insulation foams, the method comprising contacting an A-side stream of reactants that includes an isocyanate
5 with a B-side stream of reactants that include a polyol and a blowing agent, where the blowing agent includes isopentane and n-pentane in a substantial absence of cyclopentane.

INSULATION BOARDS AND METHODS FOR THEIR MANUFACTURE

FIELD OF THE INVENTION

5 This invention relates to the manufacture of polyisocyanurate insulation boards and more particularly toward the use of a certain blowing agent mixture.

BACKGROUND OF THE INVENTION

10 Polyurethane and polyisocyanurate foam insulation boards are commonly employed in the construction industry. These insulation boards are cellular in nature and typically include an insulating compound trapped within the cells of the foam. For example, it is common to produce insulation boards by employing hydrochlorofluorocarbons as a blowing agent, which thereby entraps
15 these compounds within the cell network for purposes of improving the insulating ability of the foam.

 Because fluorinated and chlorinated carbon compounds, such as hydrochlorofluorocarbons, may have a deleterious impact on the environment, many governments have or will prohibit the use of these compounds in the
20 manufacture of foam. Many alternative blowing agents have been proposed including the use of certain hydrocarbons. In particular, pentane and isomers of pentane have been employed as blowing agents with a relative degree of commercial success. For example, blends including cyclopentane together with isopentane are commonly employed as a substitute for halogenated carbon
25 compounds.

 The presence of the cyclopentane has advantageously provided useful short-term insulation values (*i.e.*, R values). Cyclopentane, however, is expensive. Also, cyclopentane is believed to partially solubilize polyurethane and polyisocyanurate polymers, and therefore its presence within the cells of the
30 insulation board may deleteriously impact dimensional stability or deleteriously impact long-term R values. Furthermore, this ability to solubilize the foam material ultimately leads to poorer or higher diffusion rates which has a deleterious effect on long-term R values.

There is therefore a need to improve upon the hydrocarbon-based blowing agent systems currently employed in the manufacture of foams, particularly polyisocyanurate foams.

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SUMMARY OF THE INVENTION

In general the present invention provides a method for producing polyisocyanurate insulation foams, the method comprising contacting an A-side stream of reactants that includes an isocyanate with a B-side stream of reactants that include a polyol and a blowing agent, where the blowing agent includes isopentane and n-pentane in a substantial absence of cyclopentane.

The present invention also includes a method for producing polyisocyanurate insulation foams, the method comprising contacting an isocyanate-reactive compound with an isocyanate compound in the presence of a blowing agent that includes both isopentane and n-pentane in the substantial absence of cyclopentane, where the isopentane is present in a weight fraction that is greater than the weight fraction of the n-pentane.

The present invention further includes a method for producing polyisocyanurate insulation foams, the method comprising contacting an A-side stream of reactants that includes an isocyanate with a B-side stream of reactants that include a polyol and a blowing agent, where the blowing agent includes isopentane and n-pentane in a substantial absence of cyclopentane, where the weight ratio of the isopentane to the n-pentane is from 7:1 to 1:1.

By employing a blowing agent system that includes isopentane and n-pentane in the substantial absence of cyclopentane, the present invention overcomes many of the problems associated with the prior art and allows for the economic and efficient manufacture of technologically useful insulation boards. To begin with, the preferred embodiments do not employ chlorinated or fluorinated carbon compounds. And, while the process employs hydrocarbon blowing agents, the substantial absence of cyclopentane provides for insulation boards that are not as susceptible to dimensional instability concerns that may be caused by cyclopentane. Moreover, the use of a blend of isopentane and n-pentane has surprisingly provided insulation boards with useful insulating efficiency despite the substantial absence of cyclopentane.

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In one aspect there is provided a method for producing isocyanurate insulation foams, the method comprising:

- (i) forming a B-side stream of reactants comprising a polyol and a blowing agent blend, where the blowing agent blend comprises isopentane and n-pentane at a weight ratio of isopentane to n-pentane of about 1:1 to about 2.7:1 in the substantial absence of cyclopentane, where said step of forming comprises introducing the polyol and the blowing agent within a pin mixer under a pressure in excess of about 80 psi and a temperature in excess of about 10 °C;
- (ii) increasing the temperature of the B-side stream of reactants to a temperature of about 16 °C to about 29 °C and a pressure of about 1800 psi to about 2400 psi;
- (iii) after said step of increasing, delivering the B-side stream of reactants to a mix head, where the temperature of the B-side stream of reactants is increased to about 27 °C to about 35 °C;
- (iv) introducing an A-side stream of reactants to the mix head at a temperature of about 29 °C to about 35 °C and a pressure of about 1800 to about 2400 psi to thereby mix with the B-side stream and form a mixture of polyisocyanurate ingredients; and
- (v) depositing the mixture of polyisocyanurate ingredients onto a laminator and allowing the mixture of polyisocyanurate ingredients to form a developing foam.

In a further aspect there is provided a method for producing polyisocyanurate insulation foams, the method comprising:

- (i) providing a blowing agent comprising isopentane and n-pentane in the substantial absence of cyclopentane, where the isopentane to n-pentane weight ratio of from 1.5:1 to 1:1;
- (ii) providing a polyol stream;
- (iii) combining the polyol stream and the blowing agent to form a B-side stream, where the B-side stream comprises about 10 to about

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- (iv) 40 parts by weight blowing agent per 100 parts by weight polyol, and where said step of combining takes place under a pressure in excess of 80 psi and at a temperature in excess of about 10 °C;
- (v) after said step of combining, increasing the pressure of the B-side stream to a pressure of about 1800 to about 2400 psi;
- (vi) providing an A-side stream comprising an isocyanate;
- (vii) increasing the pressure of the A-side stream to a pressure of about 1800 to about 2400 psi; and
- (viii) mixing the A-side stream with the B-side stream within a mix head.

In still a further aspect there is provided a method for producing polyisocyanurate insulation foams, the method comprising:

- (i) mixing a polyol and a blowing agent to form a B-side stream, where said step of mixing takes place under a pressure in excess of about 80 psi and at a temperature in excess of about 10°C, wherein the blowing agent comprises isopentane and n-pentane in a substantial absence of cyclopentane, and wherein the blowing agent has an isopentane to n-pentane weight ratio of from 1.5:1 to 1:1, and wherein the blowing agent employed is in an amount of from about 10 to about 40 parts by weight blowing agent per 100 parts by weight polyol;
- (ii) increasing the pressure of the B-side stream to about 1,800 to about 2,400 psi and heating the B-side stream of reactants to a temperature of about 16 °C to about 29 °C;
- (iii) after said steps of increasing the pressure and heating, delivering the B-side stream to a mix head;
- (iv) delivering an A-side stream that comprises an isocyanate at a pressure of about 1,800 to about 2,400 psi to a mix head; and
- (v) contacting the A-side stream and the B-side stream within the mix head.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The manufacture of polyisocyanurate or polyurethane insulation boards according to the present invention employs a blowing agent system that includes isopentane and n-pentane in the substantial absence of cyclopentane.

5 In general, and in a manner that is conventional in the art, the insulation boards of the present invention are produced by developing a polyurethane and/or polyisocyanurate foam in the presence of a blowing agent. The foam is preferably prepared by contacting an A-side stream of reagents with a B-side stream of reagents and depositing the mixture or developing foam onto a
10 laminator. As is conventional in the art, the A-side stream includes an isocyanate and the B-side includes an isocyanate-reactive compound.

The A-side stream typically only contains the isocyanate, but, in addition to isocyanate components, the A-side stream may contain flame-retardants, surfactants, blowing agents and other non-isocyanate-reactive
15 components.

Suitable isocyanates are generally known in the art. Useful isocyanates include aromatic polyisocyanates such as diphenyl methane, diisocyanate in the form of its 2,4'-, 2,2'-, and 4,4'-isomers and mixtures thereof, the mixtures of diphenyl methane diisocyanates (MDI) and oligomers thereof known in the art as
20 "crude" or polymeric MDI having an isocyanate functionality of greater than 2, toluene diisocyanate in the form of its 2,4' and 2,6'-isomers and mixtures thereof, 1,5-naphthalene diisocyanate, and 1,4'diisocyanatobenzene. Preferred isocyanate components include polymeric Rubinate 1850 (Huntsmen Polyurethanes), polymeric Lupranate M70R, and polymeric MondurTM 489N (Bayer).

25 The B-side stream, which contains isocyanate reactive compounds, may also include flame retardants, catalysts, emulsifiers/solubilizers, surfactants, blowing agents fillers, fungicides, anti-static substances, water and other ingredients that are conventional in the art.

The preferred isocyanate-reactive component is a polyol. The terms
30 polyol or polyol component include diols, polyols, and glycols, which may contain water as generally known in the art. Primary and secondary amines are suitable, as are polyether polyols and polyester polyols. Useful polyester polyols include phthalic anhydride based PS-2352 (Stepen), phthalic anhydride based polyol PS-2412 (Stepen), teraphthalic based polyol 3522 (Kosa), and a blended polyol TR

564 (Oxid). Useful polyether polyols include those based on sucrose, glycerin, and toluene diamine. Examples of glycols include diethylene glycol, dipropylene glycol, and ethylene glycol. Of these, a particularly preferred glycol is diethylene glycol. Suitable primary and secondary amines include, without limitation, ethylene diamine, and diethanolamine. The preferred polyol is a polyester polyol, and the present invention is preferably practiced in the appreciable absence of any polyether polyol. Most preferably, the ingredients are devoid of polyether polyols.

Catalysts are believed to initiate the polymerization reaction between the isocyanate and the polyol, as well as a trimerization reaction between free isocyanate groups when polyisocyanurate foam is desired. While some catalysts expedite both reactions, it is common to employ two or more catalysts to achieve both reactions. Useful catalysts include salts of alkali metals and carboxylic acids or phenols, such as, for example potassium octoate; mononuclear or polynuclear Mannich bases of condensable phenols, oxo-compounds, and secondary amines, which are optionally substituted with alkyl groups, aryl groups, or aralkyl groups; tertiary amines, such as pentamethyldiethylene triamine (PMDETA), 2,4,6-tris[(dimethylamino)methyl]phenol, triethyl amine, tributyl amine, N-methyl morpholine, and N-ethyl morpholine; basic nitrogen compounds, such as tetra alkyl ammonium hydroxides, alkali metal hydroxides, alkali metal phenolates, and alkali metal acholates; and organic metal compounds, such as tin(II)-salts of carboxylic acids, tin(IV)-compounds, and organo lead compounds, such as lead naphthenate and lead octoate.

Surfactants, emulsifiers, and/or solubilizers may also be employed in the production of polyurethane and polyisocyanurate foams in order to increase the compatibility of the blowing agents with the isocyanate and polyol components.

Surfactants serve two purposes. First, they help to emulsify/solubilize all the components so that they react completely. Second, they promote cell nucleation and cell stabilization. Typically, the surfactants are silicone copolymers or organic polymers bonded to a silicone polymer. Although surfactants can serve both functions, a more cost effective method to ensure emulsification/solubilization is to use enough emulsifiers/solubilizers to maintain emulsification/solubilization and a minimal amount of the surfactant to obtain good cell nucleation and cell stabilization. Examples of surfactants include Pelron

surfactant 9868A, Goldschmidt surfactant B8469, and CK-Witco's L 6912. U.S. Patent Nos. 5,686,499 and 5,837,742 show various useful surfactants.

Suitable emulsifiers/solubilizers include DABCO KitaneTM 20AS (Air Products), and Tergitol NP-9 (nonylphenol + 9 moles ethylene oxide).

Flame Retardants are commonly used in the production of polyurethane and polyisocyanurate foams, especially when the foams contain flammable blowing agents such as pentane isomers. Useful flame retardants include tri(monochloropropyl) phosphate, tri-2-chloroethyl phosphate, phosphonic acid, methyl ester, dimethyl ester, and diethyl ester. U.S. Patent No. 5,182,309 show useful blowing agents.

The blowing agents employed in practicing this invention include a blend of isopentane and n-pentane in the substantial absence of cyclopentane. In addition to isopentane and n-pentane, the blowing agent may optionally include other blowing agents such as alkanes, (cyclo)alkanes, hydrofluorocarbons, hydrochlorofluorocarbons, fluorocarbons, fluorinated ethers, alkenes, alkynes, carbon dioxide, and noble gases.

Suitable alkanes and (cyclo)alkanes include neopentane, n-butane, cyclobutane, methylcyclobutane, isobutane, propane, cyclopropane, methylcyclopropane, n-hexane, 3-methylpentane, 2-methylpentane, cyclohexane, methylcyclopentane, n-heptane, 2-methylheptane, 3-ethylpentane, 2,2,3-trimethylbutane, 2,2-dimethylpentane, cycloheptane, methylcyclohexane and 2,3-dimethylbutane.

Suitable hydrofluorocarbons include 1,1,1,2-tetrafluoroethane (HFC 134a), 1,1,1,4,4,4-hexafluorobutane (HFC 356), pentafluoroethane (HFC 125), 1,1-difluoroethane (HFC 152a), trifluoromethane (HFC 23), difluoromethane (HFC 32), trifluoroethane (HFC 143) and 1,1,1,3,3-pentafluoropropane (HFC 245FA), fluoromethane.

Suitable hydrochlorofluorocarbons include chlorodifluoromethane (HCFC 22), 1-chloro-1,1-difluoroethane (HCFC 142b), 1,1,1-trifluoro-2,2-dichloroethane (HCFC 123) and dichlorofluoromethane (HCFC 21).

Suitable fluorocarbons include perfluoromethane (R14), perfluorocyclobutane, perfluorobutane, perfluoroethane and perfluoropropane.

Suitable hydrochlorofluorocarbons include chlorodifluoromethane (HCFC 22), 1-chloro-1,1-difluoroethane (HCFC 142b), 1,1,1-trifluoro-2,2-dichloroethane (HCFC 123) and dichlorofluoromethane (HCFC 21).

5 Suitable fluorocarbons include perfluoromethane (R14), perfluorocyclobutane, perfluorobutane, perfluoroethane and perfluoropropane.

10 Suitable fluorinated ethers include bis-(trifluoromethyl) ether, trifluoromethyl difluoromethyl ether, methyl fluoromethyl ether, methyl trifluoromethyl ether, bis(difluoromethyl) ether, fluoromethyl difluoromethyl ether, methyl difluoromethyl ether, bis-(fluoromethyl) ether, 2,2,2-trifluoroethyl difluoromethyl ether, pentafluoroethyl trifluoromethyl ether, pentafluoroethyl difluoromethyl ether, 1,1,2,2-tetrafluoroethyl difluoromethyl ether, 1,2,2,2-tetrafluoroethyl fluoromethyl ether, 1,2,2-trifluoroethyl difluoromethyl ether, 1,1-difluoroethyl methyl ether and 1,1,1,3,3,3-hexafluoroprop-2-yl fluoromethyl ether.

15 Suitable noble gases include krypton, argon and xenon. Preferred blowing agents include those having zero ozone depletion potential.

While blowing agents may also be added, although it is preferred that the blowing agent mixture is devoid of halogenated blowing agents, and it is especially preferred that the blowing agent mixture is essentially devoid of hydrofluorocarbons and hydrochlorofluorocarbons.

20 With respect to the amount of isopentane to n-pentane, it is preferred to employ an isopentane to n-pentane weight ratio of 9:1 to about 1:2, more preferably from 7:1 to 1:1, more preferably from about 5:1 to 1.5:1, even more preferably from about 4:1 to 1.7:1, still more preferably 3:1 to about 3:1, and even more preferably 2.7:1 to about 2.3:1. Preferably, the blend includes a greater weight fraction of isopentane. While other blowing agents can be employed, it is preferred that the blowing agents comprise at least 90% weight of the mixture of isopentane and n-pentane, and even more preferably at least about 95% of the mixture of isopentane and n-pentane.

30 In order to achieve the benefits of this invention, there should be a substantial absence of cyclopentane. In other words, the ingredients, especially the blowing agents, should not contain more than an insubstantial amount of cyclopentane.

In a preferred embodiment, the ingredients, especially the blowing agents, will include only trace amounts or less of cyclopentane. More preferably, the blowing agent mixture may only include less than 1.0 weight % cyclopentane, more preferably less than 0.5 weight % cyclopentane, and even more preferably less than 0.1 weight % cyclopentane.

Practice of the present invention generally does not alter the amount of any ingredient employed or the relative ratios of any of the ingredients. In general, an excess of isocyanate to polyol is employed, especially where an isocyanurate foam is desired. For example, where a polymeric isocyanate is employed as the A-side reactant, about 150 to about 300 parts by weight of polymeric isocyanate per 100 parts by weight of polyol is employed (php).

The blowing agent mixture, which includes the mixture of isopentane and n-pentane, as well as any additional blowing agents that may be employed, should be employed in an amount from about 10 to about 40 parts by weight blowing agent php, and even more preferably in an amount from about 15 to about 35 parts by weight blowing agent php.

With regard to the other ingredients, it is preferred to employ from about 0.5 to about 6 parts by weight surfactant php, from about 0.1 to about 2 parts by weight water php and from about 0 to about 25 parts by weight flame retardant php. The amount of catalyst employed may vary greatly depending on the type or nature of the catalyst, but it is typically common to employ from about 1 to about 7 parts by weight metal salt php and about 0.1 to about 3 parts by weight amine php.

Besides employing the mixture of isopentane and n-pentane in the substantial absence of cyclopentane, practice of this invention does not necessarily alter the procedures employed in preparing foam insulation boards.

For example, the process employed may include conventional low pressure mixing whereby the B-side reactants and blowing agent are mixed under atmospheric pressure and at temperatures of about 18°C to about 29°C. The B-side mixture is then delivered to a mix head at a temperature of about 18°C to about 29°C and a pressure of about 25 psi to about 200 psi. The A-side stream is likewise delivered to the same mix head at a temperature of about 18°C to about 38°C and a pressure of about 25 psi to about 200 psi. The A-side and B-side reactants undergo mixing at this mix head and the resulting mixture becomes a

developing foam that is deposited onto a laminator. The laminator may include a facer material onto which the developing foam is deposited. A second facer material may optionally be applied to the upper surface of the developing foam. The ultimate size of the resultant foam board is manipulated by adjusting the height of the moving form, *i.e.*, restrained rise, by adjusting the sides of the moving form to a desired width, and by cutting the continuous foam product to a desired length.

In a preferred embodiment, the process includes high pressure mixing whereby the B-side reactants and blowing agents are mixed within a dynamic pin mixer at pressures in excess of about 80 psi at temperatures in excess of 10°C. This particular procedure is disclosed in a co-pending international patent that designates the United States (PCT/US02/06823).

After mixing at the pin mixer, the B-side reactants are heated to a temperature of about 16°C to about 29°C, and the pressure is increased to a pressure of about 1,800 to about 2,400 psi prior to delivery to the mix head where the temperature increases to about 27°C to about 35°C.

The A-side is fed to the mix head at a temperature of about 29°C to about 35°C and a pressure of about 1,800 to about 2,400 psi. After mixing at the mix head, the developing foam is likewise deposited onto a laminator.

Various modifications and alterations that do not depart from the scope and spirit of this invention will become apparent to those skilled in the art. This invention is not to be duly limited to the illustrative embodiments set forth herein.

CLAIMS

What is claimed is:

1. A method for producing polyisocyanurate insulation foams, the method comprising:
 - (i) forming a B-side stream of reactants comprising a polyol and a blowing agent blend, where the blowing agent blend comprises isopentane and n-pentane at a weight ratio of isopentane to n-pentane of about 1:1 to about 2.7:1 in the substantial absence of cyclopentane, where said step of forming comprises introducing the polyol and the blowing agent within a pin mixer under a pressure in excess of about 80 psi and a temperature in excess of about 10 °C;
 - (ii) increasing the temperature of the B-side stream of reactants to a temperature of about 16 °C to about 29 °C and a pressure of about 1800 psi to about 2400 psi;
 - (iii) after said step of increasing, delivering the B-side stream of reactants to a mix head, where the temperature of the B-side stream of reactants is increased to about 27 °C to about 35 °C;
 - (iv) introducing an A-side stream of reactants containing isocyanates to the mix head at a temperature of about 29 °C to about 35 °C and a pressure of about 1800 to about 2400 psi to thereby mix with the B-side stream and form a mixture of polyisocyanurate ingredients; and
 - (v) depositing the mixture of polyisocyanurate ingredients onto a laminator and allowing the mixture of polyisocyanurate ingredients to form a developing foam.
2. The method of claim 1, where the laminator comprises a facer material onto which the developing foam is deposited.

3. The method of claim 2, further comprising the step of providing a second facer material to the upper surface of the foam.
4. The method of claim 3, further comprising the step of cutting the foam to a desired length.
5. A method for producing polyisocyanurate insulation foams, the method comprising:
 - (i) providing a blowing agent comprising isopentane and n-pentane in the substantial absence of cyclopentane, where the isopentane to n-pentane weight ratio of from 1.5:1 to 1:1;
 - (ii) providing a polyol stream;
 - (iii) combining the polyol stream and the blowing agent to form a B-side stream, where the B-side stream comprises about 10 to about 40 parts by weight blowing agent per 100 parts by weight polyol, and where said step of combining takes place under a pressure in excess of 80 psi and at a temperature in excess of about 10 °C;
 - (iv) after said step of combining, increasing the pressure of the B-side stream to a pressure of about 1800 to about 2400 psi;
 - (v) providing an A-side stream comprising an isocyanate;
 - (vi) increasing the pressure of the A-side stream to a pressure of about 1800 to about 2400 psi; and
 - (vii) mixing the A-side stream with the B-side stream within a mix head.
6. The method of claim 5, where said step of combining comprises combining said polyol and said blowing agent within a dynamic pin mixer.
7. The method of claim 5, where the blowing agent comprises at least about 90% by weight of the mixture of isopentane and n-pentane.

8. The method of claim 5, where the blowing agent consists essentially of isopentane, n-pentane, and optionally at least one other blowing agent having a zero ozone depletion potential.
9. The method of claim 5, where the B-side stream comprises at least one of a surfactant, water, a flame retardant, and a catalyst.
10. The method of claim 5, where said step of mixing the A-side stream and the B-side stream forms a mixture of polyisocyanurate ingredients, and further comprising depositing the mixture of polyisocyanurate ingredients onto a laminator and allowing the mixture of polyisocyanurate ingredients to form a developing foam.
11. The method of claim 6, after said step of combining the B-side stream within a dynamic pin mixer, heating the B-side stream to a temperature of about 16 °C to about 29 °C.
12. The method of claim 11, further comprising the step of delivering the B-side stream to the mix head at a temperature of about 27 °C to about 35 °C.
13. A method for producing polyisocyanurate insulation foams, the method comprising:
 - (i) mixing a polyol and a blowing agent to form a B-side stream, where said step of mixing takes place under a pressure in excess of about 80 psi and at a temperature in excess of about 10°C, wherein the blowing agent comprises isopentane and n-pentane in a substantial absence of cyclopentane, and wherein the blowing agent has an isopentane to n-pentane weight ratio of from 1.5:1 to 1:1, and wherein the blowing agent employed is in an amount of from about 10 to about 40 parts by weight blowing agent per 100 parts by weight polyol;

- (ii) increasing the pressure of the B-side stream to about 1,800 to about 2,400 psi and heating the B-side stream of reactants to a temperature of about 16 °C to about 29 °C;
 - (iii) after said steps of increasing the pressure and heating, delivering the B-side stream to a mix head;
 - (iv) delivering an A-side stream that comprises an isocyanate at a pressure of about 1,800 to about 2,400 psi to a mix head; and
 - (v) contacting the A-side stream and the B-side stream within the mix head.
14. The method of claim 13, where the B-side stream of reactants further comprises water in an amount from about 0.1 to about 2.0 parts by weight per 100 parts polyol.
15. The method of claim 13, where the blowing agent comprises less than 1.0 weight % cyclopentane.
16. The method of claim 13, where the blowing agent comprises less than 0.5 weight % cyclopentane.
17. The method of claim 13, where the step of contacting mixes the A-side and B-side streams forms a mixture of polyisocyanurate ingredients, and further comprising depositing the mixture of polyisocyanurate ingredients onto a laminator and allowing the mixture of polyisocyanurate ingredients to form a developing foam.