(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 May 2010 (06.05.2010)

PCT

(10) International Publication Number
WO 2010/051448 A1

(51) **International Patent Classification**:
B29C 44/02 (2006.01)

(21) **International Application Number**:
PCT/US2009/062767

(22) **International Filing Date**:
30 October 2009 (30.10.2009)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
61/109,773 30 October 2008 (30.10.2008) US
61/110,258 31 October 2008 (31.10.2008) US

(71) **Applicant** *(for all designated States except US)*: **JOHNSON CONTROLS TECHNOLOGY COMPANY** [US/US]; 915 East 32nd Street, Holland, MI 49432 (US).

(72) **Inventors; and**

(75) **Inventors/Applicants** *(for US only)*: **MCEVOY, James, T.** [US/US]; 2250 Karen Drive, Howell, MI 48855 (US). **METCALFE, Murray, D.** [CA/CN]; Building 26, Sifang Xijiao Garden Villa, Lane 8, Weining Road, Shanghai, PRC 200036 (CN). **LI, William, W.** [US/US]; 4687 Sycamore Drive, Ypsilanti, MI 48197 (US). **HAIFENG, Ni** [CN/CN]; Xufeng Li #14-203, Wuxi, China 214026 (CN). **McCLARREN, Patricia, J.** [US/US]; 514 Lynne avenue, Ypsilanti, MI 48198 (US).

(74) **Agent**: **VANOPHEM, John, A.**; Butzel Long IP Docketing Department, 350 South Main Street, Suite 300, Ann Arbor, MI 48104 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE,

[Continued on next page]

(54) **Title**: PALM OIL-BASED POLYURETHANE FOAM PRODUCTS AND METHOD OF PRODUCTION

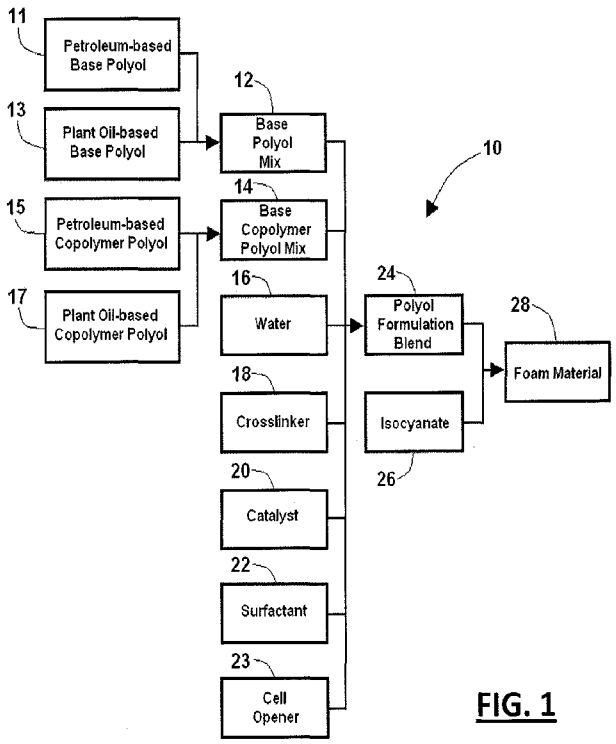

FIG. 1

(57) **Abstract**: A foam product, such as for use in a seat such as a seat -cushion, includes an open cell, polyurethane foam material produced from the reaction of an isocyanate material and at least a base polyol including at least a portion of a palm oil-based polyol, a copolymer polyol, water, one or more crosslinkers, a cell opener, catalyst or catalyst package, and a surfactant

WO 2010/051448 A1

ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

PALM OIL-BASED POLYURETHANE FOAM PRODUCTS AND METHOD OF PRODUCTION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of and priority to U.S. Provisional Patent Application No. 61/109,773, filed October 30, 2008, titled: PALM OIL-BASED POLYURETHANE FOAM PRODUCTS AND METHOD OF PRODUCTION, in the name of McEvoy et al. and to U.S. Provisional Patent Application No. 61/110,258, filed October 31, 2008, titled: PALM OIL-BASED POLYURETHANE FOAM PRODUCTS AND METHOD OF PRODUCTION, in the name of McEvoy et al., which are incorporated by reference herein.

BACKGROUND

[0002] The present disclosure relates generally to open cell, polyurethane foam formulations having non-petroleum based or initiated polyol materials and methods for making foam products including such materials. The present disclosure relates more particularly to open cell, polyurethane foam formulations having a palm oil-based polyol portion and a petrochemical-based polyol portion, and to a method for producing foam products for use in a variety of applications including in particular in a vehicle seat.

[0003] It is generally known to provide a foam cushion for the comfort of an occupant of a seat, whether the seat is a piece of furniture, a piece of equipment, or a vehicle, such as an automobile. It is also generally known to formulate the constituent parts of the foam for such a cushion from petroleum initiated, oil-based polyurethane materials that are reacted with other products to make a foam cushion product.

[0004] It is known to derive and utilize materials in the foam formulation process from renewable sources such as soybean, castor, and canola oils. However, despite such knowledge, there remains a lack of commercially viable foam product, including in seating applications, utilizing any meaningful amount of plant oil-based source materials instead of petroleum oil-based materials because it has been unknown how to produce foam products that will meet current petroleum-based performance specifications (including mechanical properties, tensile, tear, elongation, compression set, stress strain [hysteresis loss]) and comfort requirements for such seating applications.

[0005] Accordingly, there is, and there remains, a need to provide a plant oil-based polyurethane foam that can meet the specification requirements for use in various applications, including, without limitation, seating applications in the automotive industry.

SUMMARY

[0006] The specification discloses a non-petroleum-based polyol that is preferably made from natural, more readily renewable resources such as plant oils, and in particular palm oil. In one exemplary embodiment, an open cell, polyurethane foam material is provided from the reaction products of a polyol material including a palm oil-based polyol (with approximately 10% to approximately 90%, and preferably from approximately 22% to approximately 70%, bio-content) present in the polyol in an amount of between 1 and 30 parts per hundred polyol, an isocyanate, a blowing agent, a cell opener, water, and a cross linker(s), to provide a foam material well suited to various applications, including seating applications.

[0007] The exemplary embodiment is capable of producing automotive vehicle seats having at least substantially equivalent performance specifications as compared to known petroleum-based polyurethane foam materials.

[0008] Several exemplary embodiments are disclosed herein. However, it is to be understood that the disclosed embodiments are merely exemplary and may be embodied in various and alternative forms. Therefore, specific details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for the claims and/or as a representative basis for teaching one of ordinary skill in the art. Accordingly, except for otherwise expressly stated, all numerical quantities in this description indicating amounts of material are to be understood as modified by the word "substantially" in describing the broadest scope supported herein it being understood that practice within the numerical limit is preferred only.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The foregoing and other features of the exemplary embodiments will become more apparent to one of ordinary skill in the art upon consideration of the following detailed description and the accompanying drawings, in which:

[0010] FIG. 1 is a block diagram of a method to forming a foam material according to an exemplary embodiment.

[0011] FIG. 2 is a block diagram of a method of molding a component from a foam material including palm oil-based materials according to an exemplary embodiment.

[0012] FIG. 3 is a table setting forth an exemplary composition of standard cushion, back, and bolster formulations including palm oil-based materials.

[0013] FIGS. 4A and 4B are tables showing several physical properties and characteristics of foams formulated with palm oil-based polyol as compared with foams made entirely from petroleum based polyols.

DETAILED DESCRIPTION

[0014] Polyurethane-based foam products of both the soft and firm variety can, according to convention, be formed according to a "one shot" process in which, essentially, a first (typically a polyol) stream and a second (typically an isocyanate) stream are mixed and allowed to cure in a mold to form a foam product. The polyurethane-based foam product is typically composed of polyurethane-based base polyol resin, a polyurethane-based copolymer polyol (co-polyol) resin, water, a cross-linker(s), a catalyst (or catalyst package), a surfactant, a cell opener / regulator, and an isocyanate such as, for instance, TDI, MDI or blends thereof (generally, such blends are not less than 5% of either TDI or MDI; e.g., TM20, a blend of 80% TDI and 20% MDI) reacted according to a system 10 as shown in FIG. 1. Various additives can, as known, also be employed to provide different properties.

[0015] Still referring to FIG. 1, the polyurethane foaming system 10 includes the reaction of the base polyol resin blended material 12, a copolymer polyol resin blended material 14, water 16, a cross-linker material(s) 18, a catalyst material 20, a surfactant material 22, a cell opener 23 and an isocyanate material 26. The base polyol material 12 may include both petroleum-based base polyol material 11 and a palm oil-based base polyol material 13. The copolymer polyol material 14 may include both petroleum-based copolymer polyol material 15 and palm oil-based copolymer polyol material 17. The base polyol mix 12, the copolymer polyol mix 14, water 16, cross-linker material(s) 18, catalyst 20, surfactant 22 and cell opener 23 are blended to make a poly formulation blend 24. The isocyanate 26 and the polyol formulation blend 24 are mixed to form a foam material 28. The water and catalyst may be used to make a water-blown foam material, thus affecting the desired foam density.

[0016] The polyol material stream is generally composed of polyurethane polymer with, optionally, a propylene oxide "PO" that may be manufactured with potassium hydroxide (KOH) and/or then optionally ethylene oxide ("EO") capped. Another method of manufacturing polyol material includes the use of dimetal catalysts to promote the addition of free radicals. Such dimetal catalysts include, for

instance, cobalt /zinc catalyzed or cesium/rubidium catalyzed. The dimetal catalysts can have individual substitution with similar results. For instance, the rubinium catalyst may optionally be substituted for the cobalt catalyst and the cesium catalyst substituted for the zinc catalyst.

[0017] Referring to FIG. 2, the foam reaction is performed in a foaming process 40, which may be a "one shot" process according to an exemplary embodiment or may be any other suitable foaming and molding process. A first step 42 of the foaming process 40 includes mixing the components (as shown in FIG. 1) for making the foam material in a mix head but may alternatively mixed in the mold. In a simultaneous step 44, the foam material is poured into a foam mold tool having a desired shape for producing a foam product such as a seat cushion. In a third step 46, the foam material reacts in the closed mold tool and the foam product is molded in the mold tool. In a fourth step 48, the foam product is allowed to cure or harden. As part of or after the fourth step 48 and while the foam product is still in the mold tool, the foam product may be crushed to provide improved transmissibility using a time pressure release ("TPR") process in crushing step 49, as explained further below.

[0018] In a fifth step 50, after the foam product is sufficiently cured, the foam product is de-molded from the mold tool. In a sixth step 52, the de-molded, foamed product is alternatively, but preferably, crushed a pre-selected amount (% of foam thickness) for a given number of times at a pre-selected time period after de-mold. Alternatively, as described above, the product may be crushed while still in the mold. The resulting foam product may be in the shape of a block having particular dimensions or may have a particular contoured shape usable for a particular application, such as a seat base cushion, seat back cushion, armrest for cushions, or head restraint cushion, according to alternative embodiments.

[0019] According to an exemplary embodiment, at least a portion of the components for the foam making process are, as already noted, derived from more readily renewable (e.g., "green"), natural source, and more particularly from palm oil or palm kernel oil. In the exemplary embodiment, the palm oil-based polyol is derived from palm kernels. Herein, palm oil derived from either source is referred to

generically as "palm oil," and the palm-derived material is generically referred to as a "palm oil-based" material.

[0020] The palm oil-based polymer material may be processed by adding a PO to the base material. More specifically, the base polyol is constructed by the addition of PO to increase the base polyol molecular weight. This is followed by the addition of EO, with the result that the natural product content is decreased and the molecular weight is increased. The net bio-content can be anywhere from approximately 10% to approximately 90%, and preferably from approximately 22% to approximately 70%, depending on the natural oil and final composition, as well as the target molecular weight (in the illustrated embodiment, approximately 4,600).

[0021] To the extent the palm oil material is characterized by less than the conventionally preferred functionality of 3, sugar material such as sucrose or sorbitol can be added to raise the overall functionality.

[0022] In the illustrated embodiment, the palm oil-based polymer material has hydroxyl numbers preferably of from approximately 30 to 40 to provide a foam product for use in a seat cushion, an armrest cushion, a headrest, seat cover, etc.

[0023] Referring to FIG. 2, it is generally understood to mix the above-specified components by pouring two streams of the materials into a mold, closing the mold, and allowing the components to react, all as noted above. This reaction is exothermic, although auxiliary heat (approximately 150°- 170°F) is typically applied to the mold to help reduce the amount of time to cure the foam and thereby more quickly produce the foam product. After the foam is cured for a period of time (typically from 2 to 10 minutes, depending upon processing limitations or other manufacturing considerations), the foam product is optionally crushed in the mold using a TPR process. TPR includes reducing the sealing pressure of the mold to allow gas to escape the foam and mold during cure and/or prior being removed from the mold (i.e. "de-mold") and/or is then optionally, mechanically crushed (and may be repeatedly crushed) using a crushing apparatus such as a vacuum, a hard roller, or a brush crusher. The mechanical crushing apparatus applies a predetermined force to

obtain a predetermined amount of reduction in thickness at a particular time (e.g. from 15 seconds to 60 minutes, and more preferably from 90 seconds to 2 minutes) after de-mold and for a given period of crush time.

[0024] Referring next to Table 1, an exemplary polyurethane foam formulation providing exemplary ranges of the amount of constituents of the foam process (as shown in FIG. 1) is shown. As evidenced in Table 1, the base polyol and the copolymer polyol comprise the majority of the foam. Accordingly, an appreciable increase in foam material from natural renewable sources may be made by using polyols derived from a renewable source, such as palm oil.

TABLE 1: EXEMPLARY FOAM COMPOSITION

Component	Amount (parts per hundred)
Base polyol	1-99
Palm polyol	1-30
Copolymer polyol	0-98
Water	1.5-6.0
Crosslinkers	0.5-3.5
Catalyst	0.01-1.5
Surfactant	0.1-2.5
Cell opener	0-5

[0025] Exemplary components include, for the base polyol, the commercially available XSS630 (from The Dow Chemical Company, Midland, Michigan), for the palm oil-based base polyol, the commercially available 1800/6 (a 70% bio-content palm oil polyol from Maskimi Polyol Sdn. Berhad, Sekangor Darul Ehsan, Malaysia (www.maskimi.com.my)); for the copolymer polyol, the commercially available SPECFLEX NC700 (from The Dow Chemical Company, Midland, Michigan); for the cell opener, the commercially available 4053 Voranol Polyether Polyol cell opener (from The Dow Chemical Company, Midland, Michigan); catalysts include a

gellation catalyst (the commercially available diazobicydo[2.2.2]octane ("DABCO") amine catalyst TEDA 33LV (from Air Products and Chemicals, Inc., Allentown, Pennsylvania)), a balanced delayed action catalyst (the commercially available Capa 225 (C225) poly-caprolactone (from Momentive Performance Materials, Inc., Albany, New York)), a blowing catalyst (the commercially available A337 (from Momentive Performance Materials, Inc.)); for the cross-linkers, a diethanolamine ("DEOA") cross-linker and glycerin (both commercially available from Global Commodity); and for the surfactant, the commercially available L3150 (from Evonik Industries, AG, Essen, Germany) and B8715 (from Momentive Performance Materials, Inc.).

[0026] In one exemplary formulation, shown in Table 2, below, the components (such as those exemplified above), are provided in the following exemplary ranges. In respect of the crosslinkers of Table 2, exemplary ranges of each individual crosslinker (DEOA and glycerine) are, more particularly, preferably in the range of 0.5-1.5 parts per hundred DEOA and 0.3-1.2 parts per hundred for glycerine.

TABLE 2: IMPROVED EXEMPLARY FOAM COMPOSITION

Component	Amount (parts per hundred)
Base polyol	19-99
Palm polyol	1-30
Copolymer polyol	0-80
Water	2.2-4.2
Crosslinkers	0.8-2.7
Catalyst	0.2-0.6
Surfactant	0.5-1.2
Cell opener	0-2

[0027] A cell opener is most often employed when a foam is formulated for rapid cure, as this creates a high exothermic reaction resulting in foam shrinkage. A cell opener may also be used when the foam product is not able to be crushed for cost reasons, because the foam material is poured or injected behind or inside a rigid

frame, because crushing the foam product would cause appearance issues, such as with foam poured or injected behind a flexible cover stock, etc.

[0028] According to the exemplary embodiment, the foam formulation includes a high-acid polyester polyol material (polyester polyol having trace acids between 0.5% and 8.5% of the polyol) as a cell-opener. An alternative cell opener is made from high EO content polyether polyol such as Dow 4053, Bayer 9199, or Dow 1421. The cell opener is configured to open the cells of the foam by holding the water (by hydrogen bonding) / catalyst (the acid forms a salt) until an elevated temperature is reached. Because the catalyst/water is held and the reaction is delayed, soft segments (urethane) form first during the curing of the foam. When the elevated temperature is reached (e.g., as the heat of reaction increases), the blowing catalyst salt is broken to acid and catalyst and the foam cells are opened and the foam forms urea or hard segments in a more evenly distributed manner. This allows for better durability, wet set properties, and dynamic ride properties. According to current methods, extra density is often added to meet wet sets. A chemical additive may be used to reduce wet set and reduce the weight of the foam. The acid content of the palm oil acts as a cell-opener determinative of the size of the cells in the finished foam product.

[0029] It should be understood that any process disclosed in this application for the production of a natural oil-based base polyol may also be used to create a copolymer polyol as described above or with another process known in the art. The copolymer polyol material can be created with the palm oil-based polyol by the addition of stryene acrylonitrile ("SAN"), corn starch, or urea to create additional hardness in the foam system.

[0030] Referring next to FIG. 3, there are shown preferred foam compositions for the creation of foam products to perform to cushion, back, and bolster foam specifications. These foams are produced in a "one-shot" process as generally described above in the present disclosure.

[0031] Referring in particular now to FIGS. 4A and 4B, there is shown comparison data for the properties of foam products (more specifically, foam automobile seat cushions and seat backs) made according to a control sample (designated "KPC Polyol" and having 100 parts per hundred petroleum-based polyol) and a plant oil-based foam blend material (designated "KPC/NOP Polyol") having 93 parts per hundred polyol of a petroleum-based polyol and 7 parts per hundred of palm oil-based polyol. As shown, in almost all cases equivalent or improved performance for a variety of standardized tests (including, apparent density, tensile strength, elongation, tear strength, compression set, impact resilience and flammability) identified in Table 3, below, was exhibited by the foam products formulated with palm oil-based polyol.

TABLE 3

TEST DESCRIPTION/STANDARD	ACCEPTANCE CRITERIA
APPARENT DENSITY / ES-X62102/ES-X83218 4.1	
Seat Cushion	0.045 +/- 0.0075 g/cm3
Seat Back	0.035 +/- 0.0035 g/cm3
TENSILE STRENGTH TEST (Test speed: 200 mm/min) / ES-X62102/ES-X83218 4.2	
Seat Cushion (0.045 +/- 0.0045 g/cm3)	1 kgf/cm MIN
Seat Back (0.035 +/- 0.0035 g/cm3)	1 kgf/cm MIN
ELONGATION (%)	
Seat Cushion (0.045 +/- 0.0045 g/cm3)	120% Min
Seat Back (0.035 +/- 0.0035 g/cm3)	120% Min
TEAR STRENGTH TEST / ES-X62102/ES-X83218 4.3	
Seat Cushion (0.045 +/- 0.0045 g/cm3)	0.5 kgf/cm MIN
Seat Back (0.035 +/- 0.0035 g/cm3)	0.5 kgf/cm MIN
COMPRESSION SET: Seat cushion (0.045 +/- 0.0045 g/cm3) / ES-X62102/ES-X83218 4.7	
70c x 22 hours (50%)	7% Max
80c x 22 hours (75%)	25% Max
50c, 95% RH x 22 hours (50%)	35% Max

COMPRESSION SET: Seat back (0.035 +/- 0.035 g/cm3) / ES-X62102/ES-X83218 4.7

70c x 22 hours (50%)	7% Max
80c x 22 hours (75%)	25% Max
50c, 95% RH x 22 hours (50%)	35% Max

IMPACT RESILIENCE TEST / ES-X62102/ES-X83218 4.15

Seat Cushion (0.045 +/- 0.0045 g/cm3)	60% MIN
Seat Back (0.035 +/- 0.0035 g/cm3)	60% MIN

FLAMMABILITY TEST / ES-X60410

Normal State

Seat Cushion (0.045 +/- 0.0045 g/cm3)	80 mm/min MAX
Seat Back (0.035 +/- 0.0035 g/cm3)	80 mm/min MAX

[0032] Foam with increased palm oil-based polyol content as described in this disclosure may be used for many automotive applications including molded foams for seating. Seating formed from the foam described above may be used for a variety of vehicles, including but not limited to passenger vehicles (e.g., cars or automobiles, vans, sport or cross-over utility vehicles), light trucks, busses, medium trucks such as box trucks, heavy trucks, fire engines, dump trucks, landscaping vehicles, excavators, industrial vehicles, mobile cranes, armored vehicles, aircraft, and any and all other seating applications.

[0033] The palm oil-based polyol foam formulations may be used in a numerous components of the vehicle seat including the seat bolster cushion, the seat cover, the head restraint, the seat back cushion, and the seat base cushion. Further, the palm oil-based polyol foam formulations may also be used in pour-in-place manufactured components. The palm oil-based polyol foam formulations may also be used in elastomers, and items such as shoe soles and plastic replacements. And the palm oil-based polyol foam formulations may further be used in any and all other products that can be made from such material.

[0034] According to other various exemplary embodiments, the palm oil-based polyol foam formulations disclosed herein may be used for other automotive

interior components, including a headliner, a door panel, an instrument panel, a steering wheel, and carpeting.

[0035] The construction and arrangement of the elements of the processes for forming polyurethane foam shown in the various exemplary embodiments disclosed, including the best embodiment, are illustrative only. Only a few embodiments of the present disclosure are described in detail herein. Those of ordinary skill in the art who review this disclosure will readily appreciate that modifications are possible without departing from the novel teachings and advantages of the disclosure as limited only by the following claims.

WHAT IS CLAIMED IS:

1. An open cell, foam product for use in a seat application, wherein the open cell foam product is produced from the reaction product of a polyol formulation blend (24) and an isocyanate (26), wherein the polyol formulation blend (24) comprises:

a base polyol (12) including between 1 and 15 parts per hundred of a palm oil-based polyol material and a petroleum-based polyol material wherein a propylene oxide is added to the base polyol to increase its molecular weight;

a copolymer polyol (14) including between 1 and 15 parts per hundred of a palm oil-based polyol material and a petroleum-based polyol material wherein sorbitol, blended with glycerin, is added to produce a copolymer polyol;

water (16);

a crosslinker (18);

a cell opener (23);

a catalyst (20); and

a surfactant (22).

2. The foam product of Claim 1, wherein the palm oil-based polyol material includes a net bio-content of between approximately10% and 90%.

3. The foam product of Claim 2, wherein the palm oil-based polyol material includes a net bio-content of between approximately 22% and 70%.

4. The foam product of Claim 1, wherein the palm oil-based polyol material is blended with a sugar material to raise the overall functionality of the palm oil-based polyol material.

5. The foam product of Claim 4, wherein the sugar material is one of sucrose and sorbitol.

6. The foam product of Claim 1, wherein the palm oil-based polyol material has a hydroxyl number of between approximately 25 and 60.

7. The foam product of Claim 6, wherein the palm oil-based polyol material has a hydroxyl number of between approximately 30 and 40.

8. The foam product of Claim 1, wherein the cell opener is a high-acid polyester polyol material having trace acids of between approximately 0.5% and 9.5% of the polyol material.

9. The foam product of Claim 8, wherein the cell opener is a high-acid polyester polyol material having trace acids of between approximately 3.5% and 8.5% of the polyol material.

10. The foam product of Claim 1, wherein the palm oil-based polyol material has a functionality of between approximately 2.5 and 3.5.

11. The foam product of Claim 1, wherein the copolymer polyol material is a blend of between 1 and 100 parts per hundred of palm oil-based copolymer polyol and between 0 and 99 parts of petroleum oil-based copolymer polyol reacted with at least one of a styrene-acrylonitrile, corn starch, and urea to increase the hardness of the foam product.

12. A method of producing an open cell foam product, for use in a seat application, wherein the open cell foam product is produced from the reaction product of a polyol formulation blend (24) and an isocyanate (26), the method comprising the steps of:

formulating a base polyol (12) including between 5 and 15 parts per hundred of a palm oil-based polyol material (13) and a petroleum-based polyol material (11) wherein a propylene oxide is added to the base polyol (12) to increase its molecular

weight; a copolymer polyol (14) including between 5 and 15 parts per hundred of a palm oil-based polyol material (13) and a petroleum-based polyol material (11) wherein sorbitol, blended with glycerin, is added to produce a copolymer polyol (14); water (16); a crosslinker (18); a cell opener (23); a catalyst (20); and a surfactant (22);

mixing the polyol blend material (24) with a isocyanate material (26) in a mix head to create a foam material;

pouring the foam material into a foam mold tool to form a foam product;

curing the foam product so that the foam product retains its shape; and

demolding the foam product from the mold tool.

13. The method of producing a foam product of Claim 12, the method further comprising the step of crushing the foam product, after the foam material is poured into the mold tool, to provide improved transmissibility using a time-pressure release process.

14. The method of producing a foam product of Claim 13, wherein the time-pressure release process comprises reducing the sealing pressure of the mold to enable gas to escape the foam and mold during curing and prior to de-molding.

15. The method of producing a foam product of Claim 14, wherein the time-pressure release process further comprises crushing the foam product using a crushing apparatus which applies a predetermined force to obtain a predetermined amount of reduction in thickness at a predetermined timed after de-molding and for a predetermined period of crush time.

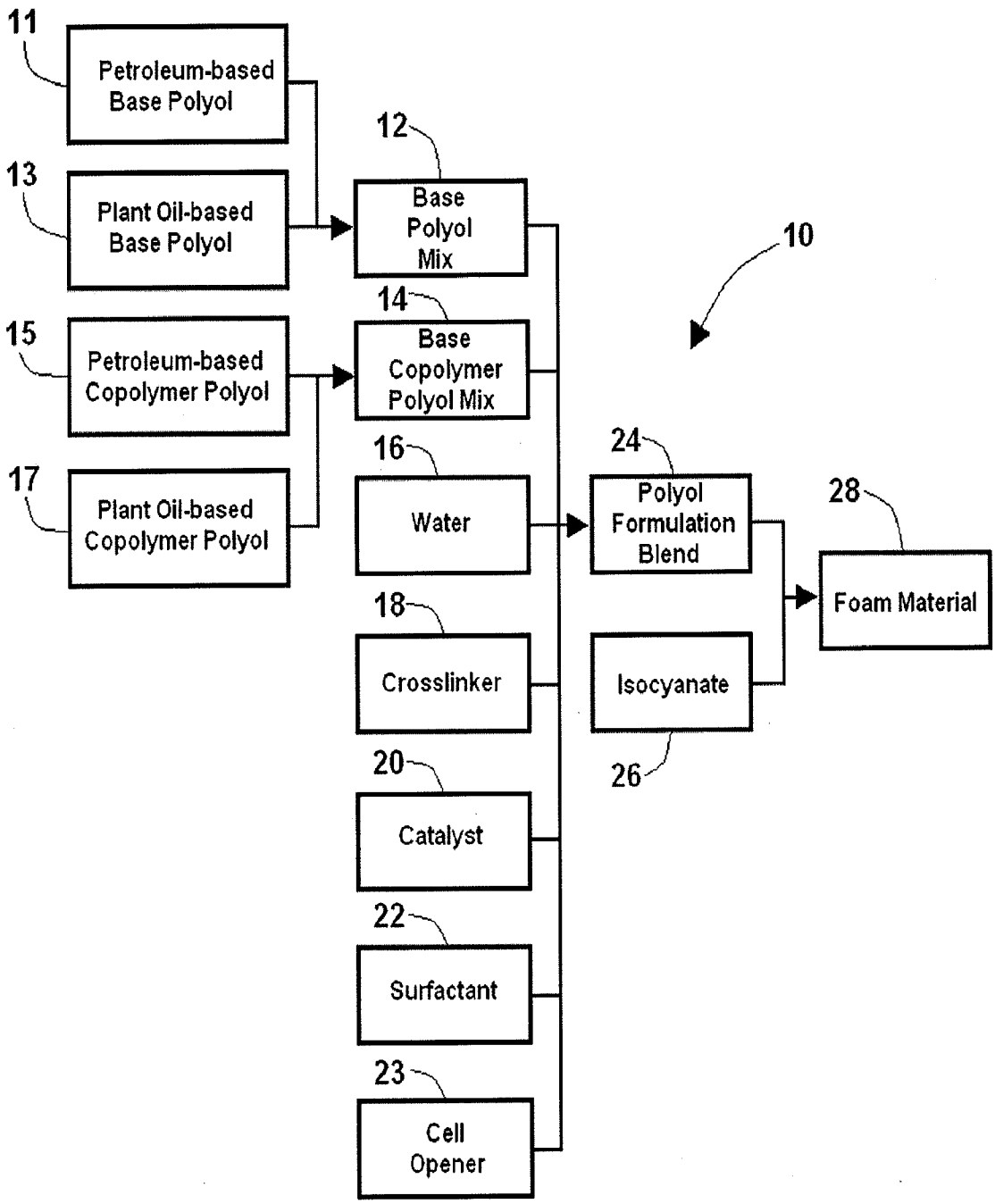
11
Petroleum-based Base Polyol
13
Plant Oil-based Base Polyol
12
Base Polyol Mix
10
15
Petroleum-based Copolymer Polyol
14
Base Copolymer Polyol Mix
17
Plant Oil-based Copolymer Polyol
16
Water
24
Polyol Formulation Blend
28
Foam Material
18
Crosslinker
Isocyanate
26
20
Catalyst
22
Surfactant
23
Cell Opener

FIG. 1

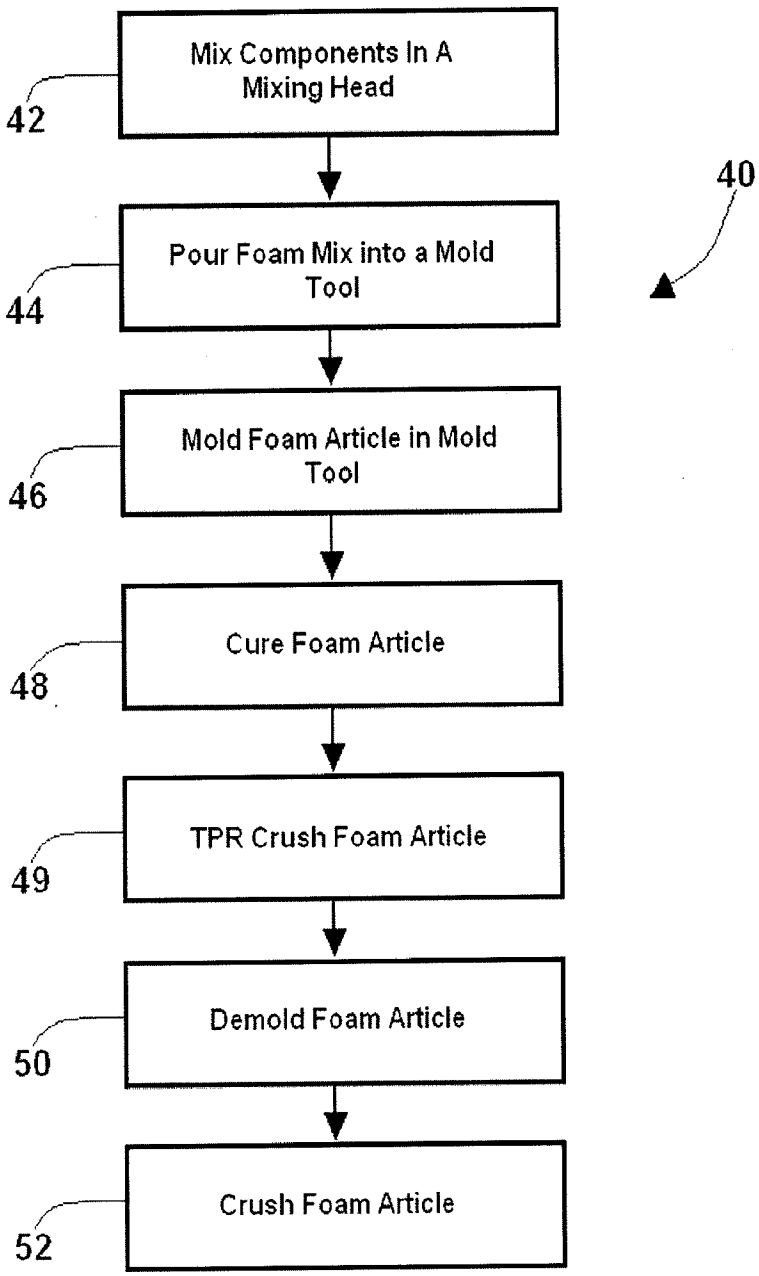
Mix Components In A Mixing Head
42
40
Pour Foam Mix into a Mold Tool
44
Mold Foam Article in Mold Tool
46
Cure Foam Article
48
TPR Crush Foam Article
49
Demold Foam Article
50
Crush Foam Article
52

FIG. 2

Material	Back (PPH)	Cushion (PPH)	Bolster (PPH)
XSS630	65-85	40-60	10.0-40
NC700	10-20	30-40	55-75
Palm NOP	5-15	10-30	5-15
Water	3.5-4.5	2.5-3.2	1.8-2.8
DEOA LF	0.5-2.5	0.5-2.5	0.5-2.5
33 LV	0.15-0.45	0.15-0.45	0.15-0.45
C225	0.1-0.3	0.1-0.3	0.1-0.3
A337	0.05-0.25	0.05-0.25	0.05-0.25
B8715	0.2-0.8	0.2-0.8	0.2-0.8
L3150	0.1-0.6	0.1-0.6	0.1-0.6

FIG. 3

Test Description Provide a brief description of each test. Include SC/CC Symbol List the Customer or ASG designated symbol if applicable	Acceptance Criteria Specify test targets and/or pass/not pass criteria. e.g. cycles, miles, volts, minimum value, no breakage etc.	Test Phase ED = Engineering Devel't Testing DV = Design Verification PV = Production Validation CCT = Continued Compliance Testing	Target Requirements State required probability or reliability and confidence of meeting acceptance criteria, e.g. R90 C90, or All must pass	Sample Type Describe the sample to be tested	Actual Results List results in terms of reliability or probability as appropriate	Additional Notes Describe or elaborate on sub-phases

Test Plan												Test Report			
Test ID	Specification & Test Method	Test Description	Acceptance Criteria	Test Phase	Target Requirements	Test Responsibility	Timing Est. Start	Timing Est. Comp.	Sample Qty	Sample Type	Timing Act. Comp.	Sample No	Sample Level	Pass/ Not Pass	Actual Results	Additional Notes
5444	ES-X62102 ES-X83218 4.1	APPARENT DENSITY a) Seat Cushion	a) 0.045 +/- 0.0075 g/cm3	PV	ALL MUST PASS	JCM	7-Jul-08	8-Jul-08	5pcs	100mm X 100mm X 50mm	11-Jul-08	1	D		KPC/NOP POLYOL 0.045-0.0463	
5445							7-Jul-08	8-Jul-08	5pcs		11-Jul-08	2	D		KPC POLYOL 0.0426-0.0446	
5446		b) Seat back	b) 0.035 +/- 0.0035 g/cm3				7-Jul-08	8-Jul-08	5pcs	100mm X 100mm X 50mm	11-Jul-08	3	D		KPC/NOP POLYOL 0.0154-0.0365	
5447							7-Jul-08	8-Jul-08	5pcs		11-Jul-08	4	D		KPC POLYOL 0.032-0.0362	
5448	ES-X62102 ES-X83218 4.2	TENSILE STRENGTH TEST (kgf/cm MIN) Test speed: 200mm/min a) Seat cushion	1.0 kgf/cm MIN	PV	ALL MUST PASS	JCM	14-Jul-08	16-Jul-08	5pcs		17-Jul-08	5	D		KPC/NOP POLYOL 2.753-2.891 kgf/cm MIN	No.5 Specified in JIS K6251 or ISO37 Thicknes : 10mm
5449			a) 0.045 +/- 0.0045 g/cm3				14-Jul-08	16-Jul-08	5pcs		17-Jul-08	6	D		KPC POLYOL 2.075-2.585 kgf/cm MIN	
5450		b) Seat back	b) 0.035 +/- 0.0035 g/cm3				14-Jul-08	16-Jul-08	5pcs		17-Jul-08	7	D		KPC/NOP POLYOL 1.734-2.106 kgf/cm MIN	

FIG.4A

Test Description	Acceptance Criteria	Test Phase	Target Requirements	Sample Type	Actual Results	Additional Notes
Provide a brief description of each test. Include SC/CC Symbol List the Customer or ASG designated symbol if applicable	Specify test targets and/or pass/not pass criteria. e.g. cycles, miles, volts, minimum value, no breakage etc.	ED = Engineering Devel't Testing DV = Design Verification PV = Production Validation CCT = Continued Compliance Testing	State required probability or reliability and confidence of meeting acceptance criteria, e.g. R90 C90, or All must pass	Describe the sample to be tested	List results in terms of reliability or probability as appropriate	Describe or elaborate on sub-phases

Test Plan											Test Report					
Test ID	Specification & Test Method	Test Description	Acceptance Criteria	Test Phase	Target Requirements	Test Responsibility	Timing Est. Start	Timing Est. Comp.	Sample Qty	Sample Type	Timing Act. Comp.	Sample No	Sample Level	Pass/ Not Pass	Actual Results	Additional Notes
5450-1							14-Jul-08	16-Jul-08	5pcs		17-Jul-08	8	D		KPC POLYOL 1.683-1.973 kgf/cm MIN	
5448		ELONGATION (%)		PV	ALL	JCM	14-Jul-08	16-Jul-08	5pcs		17-Jul-08	9	D		KPC/NOP POLYOL	
		a) Seat Cushion	120% Min		MUST PASS										133.3-162.6%	
5449							14-Jul-08	16-Jul-08	5pcs		17-Jul-08	10	D		KPC POLYOL 123.3-159.6%	
5450		b) Seat back	120% Min				14-Jul-08	16-Jul-08	5pcs		17-Jul-08	11	D		KPC/NOP POLYOL 123.3-159.0%	
5450-1							14-Jul-08	16-Jul-08	5pcs		17-Jul-08	12	D		KPC POLYOL 120.0-146.1%	
5451	ES-X62102 ES-X83218 4.3	TEAR STRENGTH TEST (kgf/cm MIN)	0.5 kgf/cm MIN	PV	ALL MUST PASS	JCM	16-Jul-08	18-Jul-08	5pcs		18-Jul-08	13	D		KPC/NOP POLYOL 0.229-1.792 kgf/cm MIN	Angular shape without notch, Specified in JIS K6252 or ISO34 Thickness : 10mm
		a) Seat cushion	0.045 +/- 0.0045 g/cm3													
5452							16-Jul-08	18-Jul-08	5pcs		18-Jul-08	14	D		KPC POLYOL 1.020-1.792 kgf/cm MIN	
5453		b) Seat back	0.035 +/- 0.0035 g/cm3				16-Jul-08	18-Jul-08	5pcs		18-Jul-08	15	D		KPC/NOP POLYOL 0.576-1.781 kgf/cm MIN	
5454							16-Jul-08	18-Jul-08	5pcs		18-Jul-08	16	D		KPC POLYOL 6.749-1.025 kgf/cm MIN	

FIG.4B

Test Description Provide a brief description of each test. Include SC/CC Symbol List the Customer or ASG designated symbol if applicable	Acceptance Criteria Specify test targets and/or pass/not pass criteria. e.g. cycles, miles, volts, minimum value, no breakage etc.	Test Phase ED = Engineering Develt Testing DV = Design Verification PV = Production Validation CCT = Continued Compliance Testing	Target Requirements State required probability or reliability and confidence of meeting acceptance criteria, e.g. R90 C90, or All must pass	Sample Type Describe the sample to be tested	Actual Results List results in terms of reliability or probability as appropriate	Additional Notes Describe or elaborate on sub-phases

Test Plan											Test Report			
Test ID	Specification & Test Method	Test Description	Acceptance Criteria	Test Phase	Target Requirements	Test Responsibility	Timing Est. Start	Timing Est. Comp.	Sample Qty	Sample Type	Timing Act. Comp.	Sample No	Sample Level	Pass/ Not Pass	Actual Results	Additional Notes
5455	ES-X62102 ES-X83218 4.7	COMPRESSION SET a) Seat Cushion 1) 70c X 22 hours (50%)	a) 0.045 +/- 0.0045 g/cm3 7% Max	PV	ALL MUST PASS	JCM	15-Jul-08	16-Jul-08	3pcs	50mm X 50mm X 50mm	16-Jul-08	17	D		KPC/NOP POLYOL 3.8%	
5456							15-Jul-08	16-Jul-08	3pcs		16-Jul-08	18	D		KPC POLYOL 4.26%	
5459		2) 80c X 22 hours (75%)	25% Max				16-Jul-08	17-Jul-08	3pcs	50mm X 50mm X 50mm	17-Jul-08	19	D		KPC/NOP POLYOL 17.1%	
5460							16-Jul-08	17-Jul-08	3pcs		17-Jul-08	20	D		KPC POLYOL 17.2%	
5453		3) 50c, 95% RH X 22 hours (50%)	35% Max				15-Jul-08	16-Jul-08	3pcs	50mm X 50mm X 50mm	16-Jul-08	21	D		KPC/NOP POLYOL 10.3%	
5454							15-Jul-08	16-Jul-08	3pcs		16-Jul-08	22	D		KPC POLYOL 9.2%	
5457	ES-X62102 ES-X83218 4.7	COMPRESSION SET b) Seat back 1) 70c X 22 hours (50%)	b) 0.035 +/- 0.0035 g/cm3 7% Max	PV	ALL MUST PASS	JCM	15-Jul-08	16-Jul-08	3pcs	50mm X 50mm X 50mm	16-Jul-08	23	D		KPC/NOP POLYOL 3.53%	

FIG.4C

Test Description Provide a brief description of each test. Include SC/CC Symbol List the Customer or ASG designated symbol if applicable	Acceptance Criteria Specify test targets and/or pass/not pass criteria. e.g. cycles, miles, volts, minimum value, no breakage etc.	Test Phase ED = Engineering Devel't Testing DV = Design Verification PV = Production Validation CCT = Continued Compliance Testing	Target Requirements State required probability or reliability and confidence of meeting acceptance criteria, e.g. R90 C90, or All must pass	Sample Type Describe the sample to be tested	Actual Results List results in terms of reliability or probability as appropriate	Additional Notes Describe or elaborate on sub-phases

Test Plan											Test Report				
Test ID	Specification & Test Method	Test Description	Acceptance Criteria	Test Phase	Target Requirements	Test Responsibility	Timing Est. Start	Timing Est. Comp.	Sample Qty	Sample Type	Timing Act. Comp.	Sample No	Sample Level	Pass/ Not Pass	Actual Results	Additional Notes
5458							15-Jul-08	16-Jul-08	3pcs		16-Jul-08	24	D		KPC POLYOL 2.73%	
5461		2) 80c X 22 hours (75%)	25% Max.				16-Jul-08	17-Jul-08	3pcs	50mm X 50mm X 50mm	17-Jul-08	25	D		KPC/NOP POLYOL 12.70%	
5462							16-Jul-08	17-Jul-08	3pcs		17-Jul-08	26	D		KPC POLYOL 12.0%	
5465		3) 50c, 95% RH X 22 hours (50%)	35% Max				15-Jul-08	16-Jul-08	3pcs	50mm X 50mm X 50mm	16-Jul-08	27	D		KPC/NOP POLYOL 8.53%	
5466							15-Jul-08	16-Jul-08	3pcs		16-Jul-08	28	D		KPC POLYOL 8.4%	
5467	ES-X62102 ES-X83218 4.15	IMPACT RESILIENCE TEST (%) a) Seat cushion	60% MIN a) 0.045 +/- 0.0045 g/cm3	PV	ALL MUST PASS	JCM	9-Jul-08	10-Jul-08	3pcs	100mm X 100mm X 50mm	14-Jul-08	29	D		KPC/NOP POLYOL 68-63%	
5468							9-Jul-08	10-Jul-08			14-Jul-08	30	D		KPC POLYOL 61.6-65%	

FIG.4D

Test Description Provide a brief description of each test. Include SC/CC Symbol List the Customer or ASG designated symbol if applicable	Acceptance Criteria Specify test targets and/or pass/not pass criteria. e.g. cycles, miles, volts, minimum value, no breakage etc.	Test Phase ED = Engineering Devel't Testing DV = Design Verification PV = Production Validation CCT = Continued Compliance Testing	Target Requirements State required probability or reliability and confidence of meeting acceptance criteria, e.g. R90 C90, or All must pass	Sample Type Describe the sample to be tested	Actual Results List results in terms of reliability or probability as appropriate	Additional Notes Describe or elaborate on sub-phases

Test Plan												Test Report			
Test ID	Specification & Test Method	Test Description	Acceptance Criteria	Test Phase	Target Requirements	Test Responsibility	Timing Est. Start	Timing Est. Comp.	Sample Qty	Sample Type	Timing Act. Comp	Sample No	Sample Level	Pass/ Not Pass	Actual Results	Additional Notes
5469		b) Seat back	b) 0.035 +/- 0.0035 g/cm3				9-Jul-08	10-Jul-08	3pcs	100mm X 100mm X 50mm	14-Jul-08	31	D		KPC/NOP POLYOL 66.1-67.2%	
5470							9-Jul-08	10-Jul-08			14-Jul-08	32	D		KPC POLYOL 64.3-64.6%	
5471	ES-X60410	FLAMMABILITY TEST (mm/min MAX) Normal State	80 mm/min MAX	DV/PV	ALL MUST PASS	JCM	8-Jul-08	10-Jul-08	5pcs	220mm X 100mm X 12mm	11-Jul-08	33	D		KPC/NOP POLYOL 0 mm/min MAX	
5472		a) Seat cushion	a) 0.045 +/- 0.0045 g/cm3				8-Jul-08	10-Jul-08	5pcs		11-Jul-08	34	D		KPC POLYOL 0 mm/min MAX	
5473		b) Seat back	b) 0.035 +/- 0.0035 g/cm3				8-Jul-08	10-Jul-08	5pcs	220mm X 100mm X 12mm	11-Jul-08	35	D		KPC/NOP POLYOL 0 mm/min MAX	
5474							8-Jul-08	10-Jul-08	5pcs		11-Jul-08	36	D		KPC POLYOL 0 mm/min MAX	

FIG.4E

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 09/62767

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B29C 44/02 (2009.01)
USPC - 264/45.3; 521/155
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) -- B29C 44/02 (2009.01) and USPC -- 264/45.3; 521/155

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8) -- C08G 18/00 (2009.01)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWest (PGPB,USPT,USOC,EPAB,JPAB); USPTO; Espacenet; Google Patents; Google Scholar; Google -- please see extra sheet for Search Terms Used

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2006/0293400 A1 (Wiltz et al.) 28 December 2006 (28.12.2006) para [0005]; [0015]; [0017]; [0022]; [0024]; [0029]; [0030]; [0031]; [0032]; [0035]; [0058]; [0080]; [0081]; [0082]	1-15
Y	US 2003/0191274 A1 (Kurth et al.) 09 October 2003 (09.10.2003) para [0015]; [0016]; [0051]	1-15
Y	US 2007/0175793 A1 (Narine et al.) 02 August 2007 (02.08.2007) Table 2; Table 14; para [0173]; [0195]; [0196]; [0203]	6,7
Y	US 2003/0130367 A1 (Kimura et al.) 10 July 2003 (10.07.2003) para [0001]; [0036]; [0049]	10
Y	US 4,717,518 A (Cavender) 05 January 1988 (05.01.1988) col 4, ln 23-25; col 2, ln 30-35; col 4, ln 43; col 5, ln 52 to col 6, ln 14; col 16, ln 11-55	12-15
A	US 2007/0142544 A1 (Jenkines et al.) 21 June 2007 (21.06.2007) para [0007]; [0010]; [0019]; [020]; [0021];[0022]; [0024]; [0045]	1-15
A	US 5,772,936 A (Cavender) 30 June 1998 (30.06.1998) Fig 2b; col 12, ln 12-35	12-15

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 DECEMBER 2009 (16.12.2009)	24 DEC 2009
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 09/62767

Search Terms Used:

CELL OPENER CELL-OPENER COMPRESS$ CRUSH$ FOAM FUNCTIONALITY HYDROXYL NUMBER MOLD PALM OIL PALM-OIL PALM SEED PALM-SEED PALM KERNEL PALM-KERNEL PALM OIL-BASED POLYETHER POLYOL POLYOL POLYURETHANE PRESSURE SEAT SEATING TIME TIME-PRESSURE URETHANE VORANOL