



- (51) **International Patent Classification:**
C08G 18/58 (2006.01) C08G 18/40 (2006.01)
- (21) **International Application Number:**
PCT/CN2013/087974
- (22) **International Filing Date:**
27 November 2013 (27.11.2013)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (71) **Applicant: DOW GLOBAL TECHNOLOGIES LLC**
[US/US]; 2040 Dow Center, Midland, Michigan 48674 (US).
- (72) **Inventors; and**
- (71) **Applicants (for SC only): LI, Wei** [CN/CN]; Room 601, Building 10, No. 2496, East Huaxia Road, Pudong New District, Shanghai 201209 (CN). **ZHANG, Yi** [CN/CN]; 1A, No. 32, Lane 999, Changshou Road, Shanghai 200042 (CN). **LI, Jiang** [CN/CN]; Room 402, Building 42, Nong 2250 Dongjing Road, Shanghai 201208 (CN).
- (74) **Agent: WU, FENG & ZHANG CO.;** Room 305, Tower B, Beijing Aerospace CPMIEC Building, No. 30 Haidian South Road, Haidian District, Beijing 100080 (CN).

- (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, BN, 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, IR, IS, JP, KE, KG, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— with international search report (Art. 21(3))



(54) **Title:** CARDANOL MODIFIED EPOXY POLYOL

(57) **Abstract:** A reaction system for forming polyurethane elastomers includes a cardanol modified epoxy polyol. In particular, the reaction system has an isocyanate-reactive component that includes the cardanol-modified epoxy polyol and an isocyanate component that includes at least one polyisocyanate. The cardanol-modified epoxy polyol is a reaction product of an epoxy component and an epoxy-reactive component at a ratio of epoxy groups to epoxy reactive groups from 1:1 to 1:5, and the epoxy-reactive component includes a cashew nutshell liquid having a cardanol content of at least 85 wt%, based on a total weight of the cashew nutshell liquid.

CARDANOL MODIFIED EPOXY POLYOL

Field

[0001] Embodiments relate to a cardanol modified epoxy polyol and to polyurethane elastomers formed using the cardanol modified epoxy polyol.

5

Introduction

[0002] A polyurethane based product may be formed by reacting an isocyanate with a polyol. The polyol used may have at least one petroleum based building block (such as ethylene oxide and/or propylene oxide). While such petrochemical based polyols are widely used, these polyols face many problems such as exhaustion of natural resources and fluctuations in price based on changes in oil price.

10

[0003] In the epoxy based art of aqueous dispersions and coatings, it has been suggested that petrochemical based resins may be substituted with a biomass based resin that is a reaction product of an epoxy resin and a biomass derived compound such as cardanol at a ratio of epoxy groups to epoxy reactive groups from 1:0.2 to 1:0.8, e.g., as discussed in U.S. Patent No. 7,812,101.

15

However, such a partially modified biomass based resin may not be suitable for use in the polyurethane art. Accordingly, an epoxy and cardanol based formulation is sought for use as a polyol in the polyurethane art.

Summary

[0004] Embodiments may be realized by providing a reaction system for forming polyurethane elastomers that includes an isocyanate-reactive component having a cardanol-modified epoxy polyol and an isocyanate component that includes at least one polyisocyanate. The cardanol-modified epoxy polyol is a reaction product of an epoxy component and an epoxy-reactive component at a ratio of epoxy groups to epoxy reactive groups from 1:0.95 to 1:5. The epoxy-reactive component includes a cashew nutshell liquid having a cardanol content of at least 85 wt%, based on a total weight of the cashew nutshell liquid.

25

Detailed Description

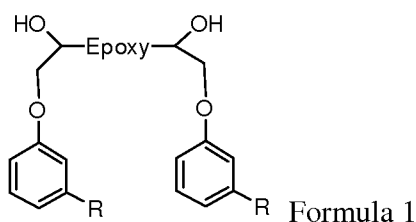
[0005] A polyurethane product (e.g., a gel polyurethane product) is formed as a reaction product of a mixture that includes an isocyanate component and an isocyanate-reactive component. The isocyanate component includes at least one polyisocyanate and the isocyanate-reactive component includes a polyol component having at least one polyol. According to 5 embodiments, the polyol component includes at least one cardanol-modified epoxy (CME) polyol. The isocyanate component and/or the isocyanate-reactive component may additionally include an optional additive component, which includes an additive such as a curative agent, a catalyst, a surfactant, a plasticizer, a filler, a solvent, a chain extender, and/or a crosslinker.

[0006] The CME polyol is a reaction product of a mixture that includes an epoxy component and an epoxy-reactive component that has a cardanol component (and may include an optional phenol or phenol derivative component). The epoxy component and/or the epoxy-reactive component may include an optional additive component (e.g., that may include an additive such as a curative agent, a catalyst, a surfactant, a plasticizer, a filler, a solvent, a chain extender, 15 and/or a crosslinker). A ratio of epoxy groups in the epoxy component to the epoxy reactive groups in the epoxy-reactive component is from 1:0.95 to 1:5.

[0007] The epoxy component for forming the CME polyol includes at least one epoxy resin. The at least one epoxy resin may account for 90 wt% to 100 wt% of the epoxy component, with any remainder being a portion or an entirety of the optional additive component. The 20 epoxy-reactive component may include at least 50 wt% (e.g., at least 60 wt%, at least 70 wt%, at least 80 wt%, at least 90 wt%, and/or 100 wt%) of the cardanol component, based on a total weight of the epoxy-reactive component. A remainder of the epoxy-reactive component may be the phenol or phenol derivative component. The cardanol component includes a cashew nutshell liquid (CNSL) that is a by-product of cashew nut processing (e.g., may be extracted from a layer 25 between a nut and a shell of a cashew nut). The CNSL has a cardanol content of at least 85 wt%, based on a total weight of the CNSL, such that the CNSL includes cardanol as a primary component and may additionally include cardol, methylcardol, and/or anacardic acid as secondary components. The CNSL may be subjected to a heating process (e.g., at the time of extraction from the cashew nut), a decarboxylation process, and/or a distillation process.

[0008] The CME polyol includes an epoxy derived backbone and at least two secondary isocyanate reactive groups, i.e., secondary hydroxyl groups, for reaction with isocyanate groups in the isocyanate component. The CME polyol may allow for adjustment of curing time, e.g., based on the slower reactivity of secondary isocyanate reactive groups relate to primary isocyanate reactive groups. The epoxy backbone may act as a building block and determine the hydroxyl functionality and chemical structure of the resultant CME polyol. Synthesis of the CME polyol includes a reaction between cardanol in the CNSL and an opened epoxy resin produced from a ring-opening reaction of the epoxy resin in the epoxy component. For example, the CME polyol includes a cardanol linkage with the ring opened epoxy resin, which results in an ether bond between the opened epoxy resin and the cardanol.

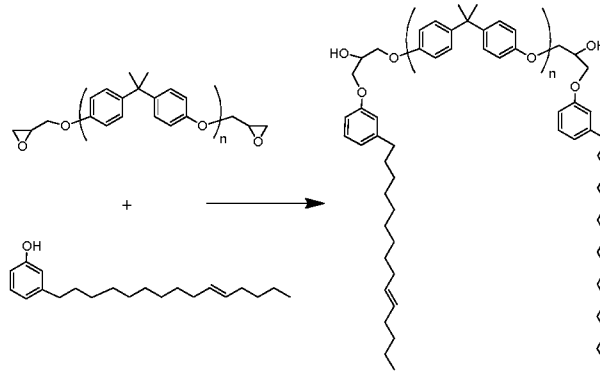
[0009] According to exemplary embodiments, the CME polyol may include a compound having the following Formula 1 when synthesis is carried out using an epoxy resin, which has two epoxide moieties and a resin backbone, and CNSL, which has therein at least mono-unsaturated cardanol:



In the above Formula 1, the R groups are independently equal to $C_{15}H_{31-n}$ (in which $n = 0, 2, 4, \text{ or } 6$) or $C_{17}H_{33-n}$ (in which $n = 0, 2, \text{ or } 4$). In particular, the R group is independently a saturated or unsaturated straight alkyl chain that includes fifteen or seventeen carbon atoms, and the CME polyol may be derived from a cardanol mixture that variously includes cardanols having different R groups. The Epoxy in Formula 1 is the resin backbone.

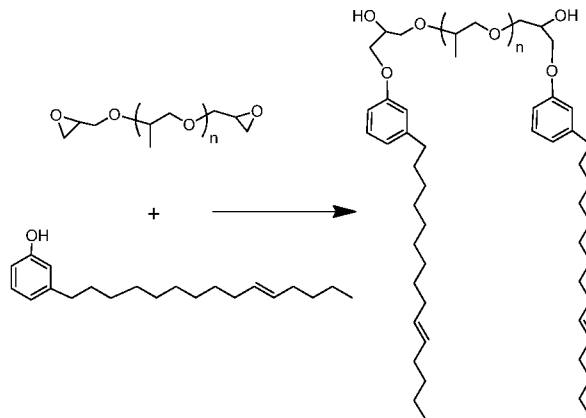
[0011] According to an exemplary embodiment, the synthesis of a CME polyol using a bisphenol A based diepoxide resin and CNSL that has therein at least mono-unsaturated cardanol, includes the following reaction stage:

5



10 [0012] According to another exemplary embodiment, the synthesis of a CME polyol using an aliphatic diepoxide epoxy resin and CNSL that has therein at least mono-unsaturated cardanol, includes the following reaction stage:

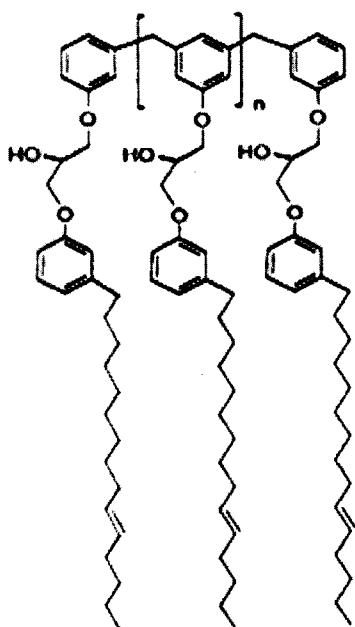
15



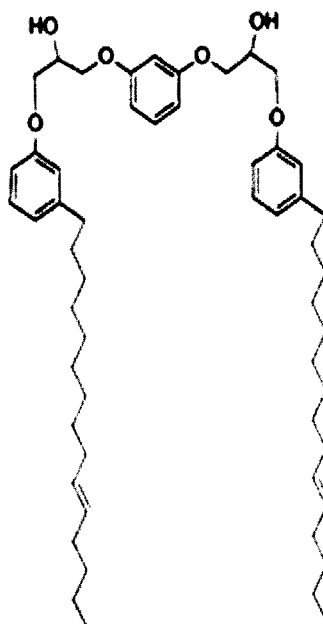
20

[0013] Other exemplary CME polyol structures that are synthesized using various aromatic epoxy resins and CNSL that has therein at least mono-unsaturated cardanol include the following:

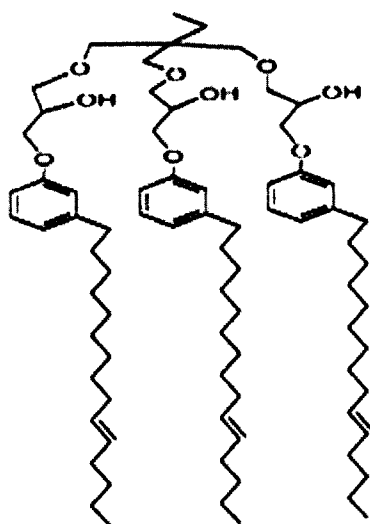
25



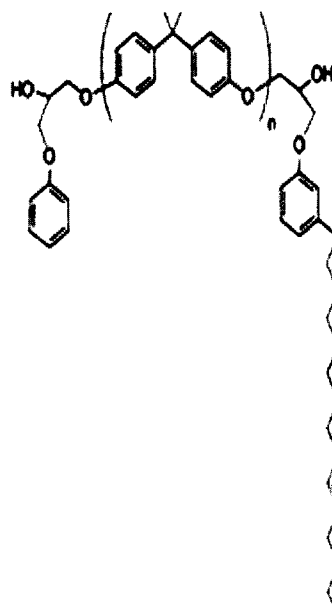
First
CME Polyol



Second
CME Polyol



Third
CME Polyol



Fourth
CME Polyol

[0014] The First CME Polyol, above, is synthesized using an aromatic polyepoxide based resin and mono-unsaturated cardanol. The Second CME Polyol, above, is synthesized using a phenyl diepoxide resin and mono-unsaturated cardanol. The Third CME Polyol, above, is synthesized using an aliphatic polyepoxide based resin and mono-unsaturated cardanol. The Fourth CME Polyol, above, is synthesized using a bisphenol A based diepoxide resin, phenol, and mono-unsaturated cardanol.

[0015] Without intending to be bound by this theory, the long chain R group of cardanol in the CME polyol may introduce hydrophobicity into the resultant polyurethane elastomers. The increased hydrophobicity may be expressed as a low water absorbance in humid conditions, e.g., a low water absorbency measured as less than 0.8 wt% (e.g., less than 0.7 wt%) increase in weight of the polyol component at the conditions of 62% humidity and 23°C for one hour. Further, hydrolysis and bubbling (e.g., the effect of bubbles being generated by carbon dioxide release from a reaction between water and an isocyanate component in the reaction mixture), may be reduced and/or avoided. The epoxy resin derived backbone of the CME polyol may provide property improvements such as mechanical performance and material compatibility to the polyurethane elastomers. Mechanical performance and/or other desired properties of the CME polyol may be adjusted in view of the alkyl chain moiety on the cardanol in the CNSL. Phenol or phenol derivatives added into the reaction mixture for forming the CME polyol may initialize the epoxy group ring-opening reaction, while the CNSL may offer hydrophobicity characteristics and anti-hydrolysis performance.

[0016] Exemplary epoxy resins for the epoxy component include polyepoxides that have at least two epoxide moieties per molecule (e.g., the epoxy resin may have a 2 to 10 epoxide functionality, a 2 to 6 epoxide functionality, a 2 to 4 epoxide functionality, etc.). The epoxy resin backbone may be saturated or unsaturated, aliphatic, cycloaliphatic, aromatic, or heterocyclic and may be substituted (e.g., contain at least one substituent such as halogen, hydroxyl, and/or ether groups). The epoxy resin may be monomeric or polymeric. The epoxy resin may have an equivalent epoxy weight (EEW) from 20 g/eq to 1000 g/eq (e.g., 30 g/eq to 800 g/eq, 50 g/eq to 600 g/eq, 100 g/eq to 500 g/eq, etc.), which EEW is the measure of the number of grams of resin for one chemical equivalent of an epoxy group. Exemplary epoxy resins include bisphenol A diglycidyl ether, bisphenol F diglycidyl ether, resorcinol diglycidyl ether, and triglycidyl ethers of para-aminophenols. The epoxy resin component may include an epoxy resin

that is commercially available, e.g., from The Dow Chemical Company under the tradenames D.E.R. and D.E.N. The viscosity and cost of the resultant CME polyol may be controlled by the choice of the epoxy resin used in the epoxy component.

[0017] The CNSL is available, e.g., from HDSG Beijing Technology under the tradename F-180 series. The CNSL includes at least 85 wt% (e.g., 85 wt% to 100 wt%, 90 wt% to 99 wt%, 91 wt% to 98 wt%, 92 wt% to 98 wt%, 93 wt% to 98 wt%, etc.) of cardanol, based on a total weight of the CNSL. The CNSL may include less than 8.5 wt% (e.g., from 0.5 wt% to 8 wt%, from 0.5 wt% to 5 wt%, 0.5 wt% to 3 wt%, etc.) of cardol, with a remainder based on a total of 100 wt% being methylcardol and/or anacardic acid. According to an exemplary embodiment, the cardanol component consists essentially of a decarboxylated CNSL that includes at least 92 wt% (e.g., 92 wt% to 100 wt%, 94 wt% to 100 wt%, etc.) of cardanol, based on a total weight of the decarboxylated CNSL. The decarboxylated CNSL may be exposed to at least one distillation process.

[0018] The optional phenol or phenol derivative component includes at least one phenol and/or at least one phenol derivative. The reaction mixture may include the optional phenol or phenol derivative component at a molar ratio from 0.5:1.5 to 1.5:0.5 (e.g., 0.8: 1.2 to 1.2:0.8, 0.9:1.1 to 1.1:0.9, etc.) for the moles of the phenol or phenol derivative to the moles of the CNSL in the reaction mixture. For example, the molar amount of the CNSL used may be reduced based on the molar amount of the phenol or phenol derivative used. Exemplary phenol derivatives include a naphthol based compound, a phenylphenol based compound, and a hexachlorophene based compound.

[0019] Exemplary catalysts for the optional additive component include quaternary ammonium compounds, phosphonium compounds, sulfonium compounds, tertiary amines, metal hydroxides, and metal alkoxides. The reaction between the epoxy component and the epoxy reactive component may be carried out neat or in the presence of an inert organic solvent. Exemplary solvents include ketone (such as methyl isobutyl ketone and/or methyl amyl ketone), toluene, xylene, and glycol ethers (such as the dimethyl ether of diethylene glycol). The reaction for forming the CME polyol may be conducted at a temperature of 120 °C to 180 °C, e.g., for 1 hour to 48 hours.

[0020] In the reaction mixture for forming the CME polyol, the ratio of epoxy groups in the epoxy component to the epoxy reactive groups in the epoxy-reactive component is from 1:0.95 to 1:5 (e.g., 1:0.98 to 1:4, 1:0.99 to 1:3, 1:1 to 1:2.5, 1:1 to 1:1.1, etc.). For example, the epoxy reactive groups provided from the cardanol component may enable sufficient conversion of the epoxy resin to the CME polyol and/or provide low viscosity to the reaction mixture (which low viscosity also enables sufficient conversion). An epoxy residue left in the resultant reaction product of the reaction mixture for forming the CME polyol, may be less than 0.2 wt%, based on a total weight of the resultant reaction product. For example, an epoxide equivalent weight of the resultant reaction product may be at least 8,000 grams/equivalent (e.g., from 9,000 g/eq to 100,000 g/eq, from 20,000 g/eq to 100,000 g/eq, from 30,000 g/eq to 100,000 g/eq, etc.), as measured according to ASTM D1652. A hydroxyl value of the resultant reaction mixture may be at least 40 mgKOH/g (e.g., from 40 mgKOH/g to 300 mgKOH/g, 60 mgKOH/g to 200 mgKOH/g, 80 mgKOH/g to 100 mgKOH/g, etc.), as measured according to ASTM D4274. The hydroxyl value may account for the CME polyol and unreacted hydroxyl groups in the epoxy-reactive component.

[0021] According to an exemplary embodiment, the reaction mixture may have full conversion (i.e., a conversion rate of at least 93 %) of the epoxy groups to hydroxyl groups when forming the CME polyol. According to exemplary embodiments, the reaction mixture that forms the CME polyol may have a conversion rate of 95% of the epoxy groups to hydroxyl groups and an EEW of at least 9,000 g/eq or a conversion rate of 98.5% of the epoxy groups to hydroxyl groups and an EEW of at least 30,000 g/eq. For example, the full conversion may be demonstrated by gel permeation chromatography (GPC) spectra characterization, which may indicate that the lower molecular weight epoxy component has essentially reacted out resulting in full conversion to the higher molecular weight CME polyol. Full conversion may be demonstrated by Fourier transform infrared (FTIR) spectrometry, which may indicate that the infrared pattern corresponding to the epoxy component is essentially not present or is present in a negligible amount in the infrared pattern corresponding to the CME polyol. Full conversion may be demonstrated by nuclear magnetic resonance spectrometry, which may indicate that the magnetic properties pattern corresponding to the epoxy component is essentially not present or is present in a negligible amount in the magnetic properties pattern corresponding to the CME polyol.

[0022] To form the polyurethane product (e.g., a gel polyurethane), a reaction mixture that includes the isocyanate-reactive component and the isocyanate component is formed. The isocyanate-reactive component includes at least the CME polyol and may optionally include at least one other polyol, which form the polyol component of the isocyanate-reactive component.

5 The at least one other polyol may be a polyether polyol or a polyester polyol. The at least one other polyol may have a petroleum based building block (e.g., propylene oxide, ethylene oxide, and/or butylene oxide) or a natural oil derived building block. For example, a propylene oxide based polyether (such as one available under the tradename VORANOL™ from The Dow Chemical Company) and/or a natural oil derived polyol (such as castor oil) may be used in the

10 isocyanate-reactive component. According to exemplary embodiments, a propylene oxide-glycerine based polyol, a poly(tetramethylene ether) glycol based polyol, a polypropylene glycol based polyol, and/or a polybutadiene based polyol may be used in the isocyanate-reactive component. For example, the isocyanate-reactive component may include at least 25 wt% of the at least one other polyol, with a remainder based on a total of 100 wt% being the CME polyol.

15 For example, the isocyanate-reactive component may include from 40 wt% to 75 wt% of the CME polyol and 25 wt% to 60 wt% of a propylene oxide based polyether (such as a propylene oxide-glycerine based polyol). According to an exemplary embodiment, the polyol component that includes the CME polyol and the at least one other polyol may have a low water absorbency measured as less than 0.8 wt% (e.g., less than 0.7 wt%) increase in weight of the polyol

20 component at the conditions of 62% humidity and 23 °C.

[0023] The isocyanate component includes at least one isocyanate such as diphenylmethane diisocyanate (MDI), toluene diisocyanate (TDI), m-phenylene diisocyanate, p-phenylene diisocyanate (PPDI), naphthalene diisocyanate (NDI), isophorone diisocyanate (IPDI), hexamethylene diisocyanate (HDI), and various isomers and/or derivatives thereof. Using at

25 least one of its 2,4'-, 2,2'-, and 4,4'-isomers, MDI may have a polymeric, a copolymer, a mixture, or a modified polymer form. Exemplary MDI products are available from The Dow Chemical Company under the trade names ISONATE, PAPI, and VORANATE. Using at least one of its 2,4 and 2,6-isomers, TDI may have a polymeric, a copolymer, a mixture, or a modified polymer form. Exemplary TDI products are available from The Dow Chemical Company under the trade

30 name VORANATE.

[0024] The isocyanate-reactive component may be reacted with the isocyanate component at an isocyanate index from 60 to 200 (e.g., 60 to 120, 80 to 150, 90 to 120, 100 to 115, etc.). For example, to make soft gel type elastomers the isocyanate index may be from 60 to 120. The isocyanate index is measured as the equivalents of isocyanate in the reaction mixture for forming the polyurethane product, divided by the total equivalents of isocyanate-reactive hydrogen containing materials in the reaction mixture, multiplied by 100. Considered in another way, the isocyanate index is the ratio of isocyanate-groups over isocyanate-reactive hydrogen atoms present in the reaction mixture, given as a percentage.

[0025] The optional additive component of the reaction mixture for forming the polyurethane product may be in its entirety or partially mixed with the isocyanate component and/or the isocyanate-reactive component. According to an exemplary embodiment, a portion of the optional additive component is added to the isocyanate-reactive component before the reaction mixture is formed and another portion is separately added to the reaction mixture.

[0026] The optional additive component may include an optional catalyst component that includes at least one catalyst. Exemplary catalysts include tertiary amines, Mannich bases formed from secondary amines, nitrogen-containing bases, alkali metal hydroxides, alkali phenolates, alkali metal alcoholates, hexahydrothiazines, and organometallic compounds. The viscosity of the isocyanate component may be reduced by the mixing diluents therewithin, e.g., diluents that are commercially available and are known to those skilled in the art may be used. Various other additives, e.g., those known to those skilled in the art, may be included in the optional additive component. For example, fillers such as inorganic and/or organic fillers, coloring agents, water-binding agents, surface-active substances, plant protection agents, extenders and/or plasticizers may be used. Optional chain extenders and/or crosslinkers may be used to modify the structure of the CME polyol.

[0027] Dyes and/or pigments (such as titanium dioxide and/or carbon black), may be included in the optional additive component to impart color properties to the polyurethane product. Pigments may be in the form of solids or a dispersion in a resin carrier. Reinforcements (e.g., flake or milled glass and/or fumed silica), may be used to impart certain properties. Other additives include, e.g., UV stabilizers, antioxidants, air release agents, and

adhesion promoters, which may be independently used depending on the desired characteristics of the polyurethane product.

[0028] According to exemplary embodiments, the polyurethane product (e.g., that includes polyurethane elastomers) may be formed by reacting the isocyanate-component with the isocyanate-reactive component to form a reaction product and curing the reaction product. The polyurethane product produced using the CME polyol may deform under pressure (i.e., reduce pressure points by redistribution of the pressure) and return to its initial state after the deformation causing pressure is removed. According to exemplary embodiments, the polyurethane product is a polyurethane gel or a viscoelastic polyurethane foam. The polyurethane product may have a density from 0.2kg/m³ to 2 kg/m³ (e.g., 0.2 kg/m³ to 1.3 kg/m³, etc.). The production of the polyurethane products may be carried out, e.g., in a mold or poured into a sheathing (such as of an elastic, flexible film, or an elastic coated textile sheet material).

[0029] According to exemplary embodiments, polyurethane elastomers may be used in gel cushions in shoes, in seating surfaces (such as sofas, chairs, car seats, and bicycle seats), in back supporting surfaces (such as beds, headrests, and armrests), protection gear (such as supports and coverings for various parts of the body), bandages and dressings, as self-adhesive/sealing materials on surfaces (such as for concrete, asphalt, and cement).

[0030] All percentages are by weight, unless indicated otherwise. All values for molecular weight are based on number average molecular weight, unless indicated otherwise.

20 Examples

[0031] The following materials are used:

D.E.R. TM 383	An aromatic epoxy resin that is a reaction product of epichlorohydrin and bisphenol A, having an epoxide equivalent weight of approximately 183g/eq (available from The Dow Chemical Company).
D.E.N. TM 438	A novolac epoxy resin that is an epichlorohydrin and phenol-formaldehyde novolac in methyl ethyl ketone, having an epoxide equivalent weight of approximately 176-181 g/eq (available from The Dow Chemical Company).

	CNSL	A cashew nutshell liquid that includes 94 wt% of cardonal (available from Hua Da SaiGao [i.e., HDSG of Beijing] Technology).
5	Catalyst A	A catalyst that includes 70 wt% ethyltriphenylphosphonium acetate in methanol (available from Alfa Aesar).
	VORANOL™CP 450	A polyether polyol that is a glycerinepropoxylatedtriol, having a number average molecular weight of 450 and a nominal hydroxyl number of 370-396 mg KOH/g (available from The Dow Chemical Company).
10	PAPI™ 27	An isocyanate of polymeric diphenylmethane diisocyanate, having an isocyanate content of 31.4 wt% (available from The Dow Chemical Company).
	Phenol	A 99 wt% solution of phenol (available from Sigma-Aldrich).

15

[0032] Firstly, a CME Polyol A is prepared by mixing D.E.R.™383 with CNSL. In particular, approximately 330 grams of CNSL is added to a 4-necked round bottom flask (equipped with thermometer, mechanical stirrer and nitrogen connection), which flask includes approximately 182 grams of D.E.R. 383, to form a reaction mixture for forming the CME polyol A. In the reaction mixture, a ratio of epoxy groups in the D.E.R.™ 383 to epoxy reactive hydroxyl groups in the CNSL is approximately 1:1.05. Then, the flask is thoroughly purged and protected with nitrogen for 10 minutes. Next, agitation of the reaction mixture within the flask is started at room temperature and approximately 0.26 grams of Catalyst A is added into the reaction mixture, during which time period agitation is continued and heat is applied to the reaction mixture. Once a temperature of 160 °C is reached, that temperature is maintained for four hours. Thereafter, nitrogen protection is continued until the reaction mixture has cooled to 40°C.

[0033] Next, properties of the resultant CME Polyol A are measured. In particular, the CME Polyol A is measured as having an epoxide equivalent weight of approximately 31,283 g/eq (as measured according to ASTM D1652) and a hydroxyl value of approximately 123 mgKOH (as

30

measured according to ASTM D4274 D). Further, GPC spectra characterization, FTIR spectrometry, and/or nuclear magnetic resonance spectrometry may be performed.

[0034] Secondly, CME Polyol B and CME Polyol C are prepared by mixing D.E.R.TM 383 with CNSL, using the method described above with respect to CME Polyol A. Working Example 1 includes CME Polyol B, which is prepared using a 1:2 ratio of D.E.R.TM 383 to CNSL, i.e., a 1:1 ratio of epoxy groups in the D.E.R.TM 383 to epoxy reactive hydroxyl groups in the CNSL. Comparative Example A includes CME Polyol C, which is prepared using a 1:1 ratio of D.E.R.TM 383 to CNSL, i.e., a 1:0.5 ratio of epoxy groups in the D.E.R.TM 383 to epoxy reactive hydroxyl groups in the CNSL. Polyurethane gel elastomers for Working Example 1 and Comparative Example A are prepared by mixing the respective CME polyols B and C with PAPITM 27 at an isocyanate index of 1.05. CME polyol properties, reaction mixture properties, and polyurethane gel properties are shown below in Table 1.

[0035] Table 1

	Working Example 1	Comparative Example A
CME Polyol Properties		
Epoxide Equivalent Weight (g/eq)	32,000	727
Epoxide Group Content (%)	0.14	6.05
Hydroxyl Group Content (%)	3.6	2.6
Reaction Mixture Properties		
Gel Time (hours)	2.5	> 48
Polyurethane Gel Properties		
Shore Hardness	60D	range from 0A to 50D
Hardness distribution	uniform	non-uniform

[0036] With respect to Table 1, above, the epoxide equivalent weight and the epoxide group content are measured according to ASTM D-1652 and the hydroxyl group content is measured according to ASTM D-4274 D. The gel time is measured as the time after the components are mixed in a mold, which mold is a plastic transparent drinking cup having a volume of 200 mL, that the resultant elastomers lose fluidity (i.e., when tilting of the mold does not result in displacement of the reaction product). Hardness is measured with a shore durometer according to ASTM 2240-05, after post-heating for three hours at 75°C and subsequent cooling to room temperature. The hardness distribution is visually inspected after removing the samples from the molds. Comparative Example A demonstrates a non-uniform distribution where the hardness

decreases from a Shore A hardness of 0 at the top of the sample to a Shore D hardness of 50 at the bottom of the sample.

[0037] Thirdly, water absorbance comparisons are conducted using 1:1 mixtures of a CME polyol with VORANOL™CP 450 to show a low water absorbency (i.e., less than 0.8% increase in weight of a polyol component at the conditions of 62% humidity and 23°C) can be achieved using a combination polyol. Comparative Example B is prepared using VORANOL™ CP 450 (V-450), without any CME polyol. Working Example 2 is prepared using a mixture of CME Polyol A and VORANOL™ CP 450. Working Example 3 is prepared using CME Polyol D and Working Example 4 is prepared using CME Polyol E, which CME Polyol D and E are prepared using the method described above with respect to forming CME Polyol A. In this regard, CME Polyol D is prepared similar to CME Polyol A, except Phenol is added to the CNSL. In particular, CME Polyol D is prepared using 165 grams of CNSL, 52 grams of Phenol, and 182 grams of D.E.R.™ 383. CME Polyol D has an epoxide equivalent weight of approximately 32,000 and a hydroxyl value of approximately 152. CME Polyol E is prepared using 330 grams of CNSL and 180 grams of D.E.N.™ 438.

[0038] Water absorbance comparisons are conducted using two pieces of A4 size printing paper under the conditions of 62% humidity and at 23 °C. Two layers of printing paper are clamped by two Teflon® rings and the spreading area of the polyol samples are fixed by the rings to an area of 250cm². Next, 30 grams of each of Working Examples 2 to 4 and Comparative Example B are independently dipped onto the printing paper and spread out on the 250cm² area inside Teflon® rings. After 1 hour, the samples are weighed to measure weight increase percent value, as shown below in Table 2.

[0039] Table 2

	Working Example 2 (1:1 weight ratio of CME Polyol A: V-450)	Working Example 3 (1:1 weight ratio of CME Polyol D: V-450)	Working Example 4 (1:1 weight ratio of CME Polyol E: V-450)	Comparative Example B (100 wt% V-450)
Weight Increase (%)	0.69	0.63	0.67	1.83

CLAIMS

1. A reaction system for forming polyurethane elastomers, the reaction system comprising:

an isocyanate-reactive component that includes a cardanol-modified epoxy polyol that is a
5 reaction product of an epoxy component and an epoxy-reactive component at a ratio of epoxy groups to epoxy reactive groups from 1:0.95 to 1:5, the epoxy-reactive component including a cashew nutshell liquid having a cardanol content of at least 85 wt%, based on a total weight of the cashew nutshell liquid, and

an isocyanate component that includes at least one polyisocyanate.

10

2. The reaction system as claimed in claim 1, wherein the cardanol content in the cashew nutshell liquid is from 90 wt% to 99 wt% and a cardol content in the cashew nutshell liquid is from 0.5 wt% to 8 wt%, based on the total weight of the cashew nutshell liquid.

15 3. The reaction system as claimed in claim 1 or claim 2, wherein the epoxy component includes from 90 wt% to 100 wt% of at least one epoxy resin having from two to four epoxide moieties per molecule, based on a total weight of the epoxy component.

4. The reaction system as claimed in any one of claims 1 to 3, wherein the
20 isocyanate-reactive component includes from 40 wt% to 75 wt% of the cardanol-modified epoxy polyol and from 25 wt% to 60 wt% of a propylene oxide based polyether, based on a total weight of the isocyanate-reactive component.

5. The reaction system as claimed in any one of claims 1 to 4, wherein the epoxy-reactive component includes a phenol or phenol derivative, a molar ratio of the cashew nutshell
25 liquid to the phenol or phenol derivative being from 0.5:1.5 to 1.5:0.5.

6. The reaction system as claimed in any one of claims 1 to 5, wherein the cardanol-modified epoxy polyol has an epoxide equivalent weight of at least 8,000 g/eq.

7. The reaction system as claimed in any one of claims 1 to 6, wherein an isocyanate index of the reaction system is from 60 to 200.

30

8. A polyurethane foam product comprising a product of the reaction system claimed in any one of claims 1 to 7.

5 9. A gel polyurethane foam comprising a product of the reaction system claimed in any one of claims 1 to 7.

10. A method of preparing polyurethane elastomers, the method comprising:
reacting the isocyanate-reactive component with the isocyanate component in the reaction system claimed in any one of claims 1 to 7 to form a reaction product, and
10 curing the reaction product to form polyurethane elastomers.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/087974

A. CLASSIFICATION OF SUBJECT MATTER

C08G 18/58(2006.01)i; C08G 18/40(2006.01)i

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)

C08G 18/58; C08G 18/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, DWPI, SIPOABS, WOTXT, CNKI, GOOGLE: PU, polyurethane, +isocyanate, CME, cardanol, +cardol???, cashew nutshell liquid, CNSL, +epoxy?, +glycid?l+, +polyol

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102482392 A (COATEX SAS) 30 May 2012 (2012-05-30) description, paragraphs [0025] to [0049]	1-10
Y	CN 102482392 A (COATEX SAS) 30 May 2012 (2012-05-30) description, paragraphs [0025] to [0049]	1-10
Y	CN 102557897 A (BEIJING ORIENTAL CLEARSKY TECHNOLOGY CO ET AL.) 11 July 2012 (2012-07-11) description, paragraphs [0004] to [0015]	1-10
Y	CN 1926165 A (BAYER METEERIAL SCIENCE AG) 07 March 2007 (2007-03-07) claims 1 to 8	1-10
Y	US 2006004115 A1 (COUNCIL SCIENT IND RES) 05 January 2006 (2006-01-05) description, paragraph [0018]	1-10
A	CN 103073689 A (CARDOLITE CHEM ZHUHAI CO LTD) 01 May 2013 (2013-05-01) the whole document	1-10

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance	“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
“E” earlier application or patent but published on or after the international filing date	“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
“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)	“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
“O” document referring to an oral disclosure, use, exhibition or other means	“&” document member of the same patent family
“P” document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

08 August 2014

Date of mailing of the international search report

25 August 2014

Name and mailing address of the ISA/

STATE INTELLECTUAL PROPERTY OFFICE OF THE
P.R.CHINA(ISA/CN)
6,Xitucheng Rd., Jimen Bridge, Haidian District, Beijing
100088 China

Authorized officer

XUE,Haijiao

Facsimile No. (86-10)62019451

Telephone No. (86-10)62085466

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2013/087974

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	102482392	A	30 May 2012	FR	2949783	B1	17 August 2012
				EP	2475697	A2	18 July 2012
				US	8541500	B2	24 September 2013
				CA	2771183	A1	17 March 2011
				FR	2949783	A1	11 March 2011
				US	2011060101	A1	10 March 2011
				EP	2475697	B1	30 July 2014
				WO	2011030197	A2	17 March 2011
				WO	2011030197	A3	03 November 2011
				CN	102557897	A	11 July 2012
CN	1926165	A	07 March 2007	JP	2007524746	A	30 August 2007
				DE	102004009818	A1	15 September 2005
				KR	20060133591	A	26 December 2006
				AT	381581	T	15 January 2008
				BR	PI0508189	A	14 August 2007
				RU	2006134266	A	10 April 2008
				EP	1723187	B1	19 December 2007
				US	7393465	B2	01 July 2008
				AU	2005217046	A1	09 September 2005
				WO	2005082967	A1	09 September 2005
				ES	2297670	T3	01 May 2008
				UA	84454	C2	27 October 2008
				US	2005192423	A1	01 September 2005
				DE	502005002292	D1	31 January 2008
CN	100471891	C	25 March 2009				
EP	1723187	A1	22 November 2006				
US	2006004115	A1	05 January 2006	US	7244772	B2	17 July 2007
CN	103073689	A	01 May 2013	Non e			