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(54) COMPOSITIONS FOR GOLF EQUIPMENT

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ABSTRACT

The present invention is directed to golf balls having at least one layer formed from a polyurea composition. The polyurea is formed by combining a polyurea prepolymer, a polyamine curative, and a tin catalyst. Golf balls of the present invention include one-piece, two-piece, multi-layer, and wound golf balls. The composition may be present in any one or more of a core layer, a cover layer, or an intermediate layer.

COMPOSITIONS FOR GOLF EQUIPMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 11/162,544, filed Sep. 14, 2005, which is a continuation-in-part of U.S. patent application Ser. No. 10/859,557, filed Jun. 2, 2004, now U.S. Pat. No. 7,105,628, the entire disclosures of which are hereby incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention is directed to polyurea compositions formed by combining a polyurea prepolymer, a polyamine curative, and a tin catalyst. The present invention is also directed to the use of such compositions in golf equipment.

BACKGROUND OF THE INVENTION

[0003] Polyureas are known to be potentially useful materials for golf ball covers. However, polyurea compositions can be difficult to process during golf ball manufacturing. For example, many polyurea systems have rapid viscosity buildup upon mixing due to their auto-catalytic nature, which does not allow enough time to adequately mix the materials and mold the parts.

[0004] Thus, a desire remains for polyurea compositions with improved processability suitable for forming golf ball layers. The present invention describes such compositions and the use thereof in a variety of golf ball layers.

SUMMARY OF THE INVENTION

[0005] In one embodiment, the present invention provides a golf ball having at least one layer formed from a polyurea composition. The composition comprises the product formed by combining a cycloaliphatic polyisocyanate prepolymer, a cycloaliphatic amine curative, and a tin catalyst.

DETAILED DESCRIPTION OF THE INVENTION

[0006] By the present invention, it has been found that the reactions of linear and cycloaliphatic-based polyisocyanates and cycloaliphatic amine curing agents can be effectively inhibited by the addition of tin compounds.

[0007] The compositions of the present disclosure typically comprise a reaction product of a polyisocyanate and one or more reactants. In one example, the reaction product can be a polyurethane formed from a polyurethane prepolymer and a curative, the polyurethane prepolymer being a reaction product of a polyol telechelic and an isocyanate. The polyol telechelic comprises at least two terminal hydroxyl end-groups that are independently primary, secondary, or tertiary. The polyol telechelic can further comprise additional hydroxyl groups that are independently located at the termini, attached directly to the backbone as pendant groups, and/or located within pendant moieties attached to the backbone. The polyol telechelic can be α,ω -hydroxy telechelics having isocyanate-reactive hydroxyl end-groups on opposing termini. All polyol telechelics are polyols, which also include monomers, dimers, trimers, adducts, and the like having two or more hydroxyl groups.

[0008] In another example, the reaction product can be a polyurea formed from a polyurea prepolymer and a curative,

the polyurea prepolymer being a reaction product of a polyamine telechelic and an isocyanate. The polyamine telechelic comprises at least two terminal amine end-groups that are independently primary or secondary. The polyamine telechelic can further comprise additional amine groups that are independently primary or secondary, and are independently located at the termini, attached directly to the backbone as pendant groups, located within the backbone, or located within pendant moieties that are attached to the backbone. The secondary amine moieties may in part form single-ring or multi-ring heterocyclic structures having one or more nitrogen atoms as members of the rings. The polyamine telechelic can be α,ω -amino telechelics having isocyanate-reactive amine end groups on opposing termini. All polyamine telechelics are polyamines, which also include monomers, dimers, trimers, adducts, and the like having two or more amine groups.

[0009] In a further example, the reaction product can be a poly(urethane-urea) formed from a poly(urethane-urea) prepolymer and a curative. The poly(urethane-urea) prepolymer can be a reaction product of an isocyanate and a blend of polyol and polyamine telechelics. Alternatively, the poly(urethane-urea) prepolymer can be a reaction product of an aminoalcohol telechelic and an isocyanate. The aminoalcohol telechelic comprises at least one primary or secondary terminal amine end-group and at least one terminal hydroxyl end-group. The polyamine telechelic can further comprise additional amine and/or hydroxyl groups that are independently located at the termini, attached directly to the backbone as pendant groups, located within the backbone, or located within pendant moieties that are attached to the backbone. The secondary amine moieties may in part form single-ring or multi-ring heterocyclic structures having one or more nitrogen atoms as members of the rings. The aminoalcohol telechelic can be α -amino- ω -hydroxy telechelics having isocyanate-reactive amine and hydroxyl end groups on opposing termini. All aminoalcohol telechelics are aminoalcohols, which also include monomers, dimers, trimers, adducts, and the like having at least one amine group and at least one hydroxyl group.

[0010] Any one or combination of two or more of the isocyanate-reactive ingredients disclosed herein can react with stoichiometrically deficient amounts of polyisocyanate such as diisocyanate to form elastomers that are substantially free of hard segments. Such elastomers can have rubber elasticity and wear resistance and strength, and can be millable.

Polyamine Telechelics

[0011] Polyamine telechelics have two, three, four, or more amine end-groups capable of forming urea linkages (such as with isocyanate groups), amide linkages (such as with carboxyl group), imide linkages, and/or other linkages with other organic moieties. As such, polyamine telechelics can be reacted with polyacids to form amide-containing polyamine or polyacid telechelics, be reacted with isocyanates to form polyurea prepolymers, and be used as curatives to cure various prepolymers. Any one or more of the hydrogen atoms in the polyamine telechelic (other than those in the terminal amine end-groups) may be substituted with halogens, cationic groups, anionic groups, silicon-based moieties, ester moieties, ether moieties, amide moieties, urethane moieties, urea moieties, ethylenically unsaturated moieties, acetylenically unsaturated moieties, aromatic moieties, heterocyclic moieties, hydroxy groups, amine groups, cyano groups, nitro

groups, and/or any other organic moieties. For example, the polyamine telechelics may be halogenated, such as having fluorinated backbones and/or N-alkylated fluorinated side chains.

[0012] Any polyamine telechelics available or known to one of ordinary skill in the art are suitable for use in compositions of the present disclosure. The M_w of the polyamine telechelics can be about 100-20,000, such as about 150, about 200, about 230, about 500, about 600, about 1,000, about 1,500, about 2,000, about 2,500, about 3,000, about 3,500, about 4,000, about 5,000, about 8,000, about 10,000, about 12,000, about 15,000, or any M_w therebetween. The polyamine telechelic can comprise one or more hydrophobic and/or hydrophilic segments.

[0013] Suitable polyamine telechelics, such as α,ω -amino telechelics, include polyamine polyhydrocarbons (e.g., polyamine polyolefins), polyamine polyethers, polyamine polyesters (e.g., polyamine polycaprolactones), polyamine polyamides (e.g., polyamine polycaprolactams), polyamine polycarbonates, polyamine polyacrylates (e.g., polyamine polyalkylacrylates), polyamine polysiloxanes, polyamine polyimines, polyamine polyimides, fatty polyamine telechelics, adduct polyamine telechelics, polyamine telechelics derived from acid-catalyzed polyols and/or polyol telechelics, derivatized polyamine telechelics, ethylenically and/or acetylenically unsaturated polyamine telechelics, and polyamine copolymers including polyamine polyolefinsiloxanes (such as α,ω -diamino poly(butadiene-dimethylsiloxane) and α,ω -diamino poly(isobutylene-dimethylsiloxane)), polyamine polyetherolefins (such as α,ω -diamino poly(butadiene-oxyethylene)), polyamine polyetheresters, polyamine polyethercarbones, polyamine polyetheramides, polyamine polyetheracrylates, polyamine polyethersiloxanes, polyamine polyesterolefins (such as α,ω -diamino poly(butadiene-caprolactone) and α,ω -diamino poly(isobutylene-caprolactone)), polyamine polyesteramides, polyamine polyestercarbones, polyamine polyesteracrylates, polyamine polyestersiloxanes, polyamine polyamideolefins, polyamine polyamidecarbones, polyamine polyamideacrylates, polyamine polyamidesiloxanes, polyamine polyamide-imides, polyamine polycarbonateolefins, polyamine polycarbonateacrylates, polyamine polycarbonatesiloxanes, polyamine polyacrylateolefins (such as α,ω -diamino poly(butadiene-methyl methacrylate), α,ω -diamino poly(isobutylene-t-butyl methacrylate), and α,ω -diamino poly(methyl methacrylate-butadiene-methyl methacrylate)), polyamine polyacrylatesiloxanes, polyamine polyetheresteramides, any other polyamine copolymers, as well as blends thereof. Examples of such polyamine telechelics include those disclosed in U.S. application Ser. No. 10/859,557, the disclosure of which is incorporated by reference in its entirety.

Polyamines

[0014] Polyamines suitable for use in the present disclosure include any and all organic compounds having two, three, four, or more amine groups in the molecule that are capable of forming urea linkages (such as with isocyanate groups) or amide linkages (such as with carboxyl group). The polyamine can be aromatic, araliphatic, aliphatic, alicyclic, heterocyclic, saturated or unsaturated, and each molecule has at least two isocyanate-reactive amine groups independently being primary or secondary. Depending on the number of isocyanate-reactive amine groups being present, polyamines may be referred to as diamines, triamines, tetramines, and other

higher polyamines. Other polyamines include fatty polyamines, alkylene polyamines, condensate polyamines, substituted and non-substituted hydrazines, sterically hindered polyamines, and regioselective polyamines. Examples of such polyamines include those disclosed in U.S. application Ser. No. 10/859,557, the disclosure of which is incorporated by reference in its entirety.

Polyol Telechelics

[0015] Any polyol telechelics available or known to one of ordinary skill in the art are suitable for use in compositions of the disclosure. Polyol telechelic such as α,ω -dihydroxy telechelics, include polyol polyhydrocarbons (such as polyol polyolefins), polyol polyethers, polyol polyesters (such as polyol polycaprolactones), polyol polyamides (such as polyol polycaprolactams), polyol polycarbonates, polyol polyacrylates (such as polyol polyalkylacrylates), polyol polysiloxanes, polyol polyimines, polyol polyimides, fatty polyol telechelics, adduct polyol telechelics, acid-catalyzed polyol telechelics, carbonate-transesterified polyol telechelics, derivatized polyol telechelics, ethylenically and/or acetylenically unsaturated polyol telechelics, and polyol copolymers including polyol polyolefinsiloxanes (such as α,ω -dihydroxy poly(butadiene-dimethylsiloxane) and α,ω -dihydroxy poly(isobutylene-dimethylsiloxane)), polyol polyetherolefins (such as α,ω -dihydroxy poly(butadiene-oxyethylene)), polyol polyetheresters, polyol polyethercarbones, polyol polyetheramides, polyol polyetheracrylates, polyol polyethersiloxanes, polyol polyesterolefins (such as α,ω -dihydroxy poly(butadiene-caprolactone) and α,ω -dihydroxy poly(isobutylene-caprolactone)), polyol polyesteramides, polyol polyestercarbones, polyol polyesteracrylates, polyol polyestersiloxanes, polyol polyamideolefins, polyol polyamidecarbones, polyol polyamideacrylates, polyol polyamidesiloxanes, polyol polyamideimides, polyol polycarbonateolefins, polyol polycarbonateacrylates, polyol polycarbonatesiloxanes, polyol polyacrylateolefins (such as α,ω -dihydroxy poly(butadiene-methyl methacrylate), α,ω -dihydroxy poly(isobutylene-t-butyl methacrylate), and α,ω -dihydroxy poly(methyl methacrylate-butadiene-methyl methacrylate)), polyol polyacrylatesiloxanes, polyol polyetheresteramides, any other polyol copolymers, as well as blends thereof. Other polyol telechelics can be derived from polyacid telechelics through reaction with polyols, aminoalcohols, and/or cyclic ethers, or derived from polyamine telechelics through reaction with hydroxy acids, cyclic esters, and/or cyclic ethers. Examples of such polyol telechelics include those disclosed in U.S. application Ser. No. 10/859,557, the disclosure of which is incorporated by reference in its entirety.

[0016] The molecular weight of the polyol telechelics can be about 100-20,000, such as about 200, about 230, about 500, about 600, about 1,000, about 1,500, about 2,000, about 2,500, about 3,000, about 3,500, about 4,000, about 5,000, about 8,000, about 10,000, or any number therebetween. The polyol telechelics can have one or more hydrophobic and/or hydrophilic segments.

Polyols

[0017] Polyols include, but are not limited to, unsaturated diols, saturated diols, alkanediols, fatty polyols, unsaturated triols, unsaturated tetraols, saturated tetraols, and other polyols. Examples of such polyols include those disclosed in U.S.

application Ser. No. 10/859,557, the disclosure of which is incorporated by reference in its entirety.

Aminoalcohol Telechelics

[0018] As used herein, the term “aminoalcohol telechelic” refers to telechelic polymers having at least one terminal amine end-group and at least one terminal hydroxyl end-group. Any such aminoalcohol telechelics available to one of ordinary skill in the art are suitable for use in compositions of the present disclosure. These telechelics can be linear, branched, block, graft, monodisperse, polydisperse, regular, irregular, tactic, isotactic, syndiotactic, stereoregular, atactic, stereoblock, single-strand, double-strand, star, comb, dendritic, and/or ionomeric, and include homopolymers, random copolymers, pseudo-copolymers, statistical copolymers, alternating copolymers, periodic copolymer, bipolymers, terpolymers, quaterpolymers, as well as derivatives of any and all polyamine telechelics, polyol telechelics, and polyacids disclosed herein. Aminoalcohol telechelics can have any of the polymer or copolymer structures of the herein-described polyamine telechelics and polyol telechelics, such as polyhydrocarbons (such as polydienes), polyethers, polyesters (such as polycaprolactones), polyamides (such as polycaprolactams), polycarbonates, polyacrylates (such as polyalkylacrylates), polysiloxanes, and copolymers thereof. Examples of such aminoalcohol telechelics include those disclosed in U.S. application Ser. No. 10/859,557, the disclosure of which is incorporated by reference in its entirety.

Aminoalcohols

[0019] Aminoalcohols useful in the present disclosure include any and all monomers, oligomers, and polymers having at least one free isocyanate-reactive hydroxy group and at least one free isocyanate-reactive amine group. The hydroxy and amine groups may be primary or secondary, terminal or pendant groups on the oligomeric or polymeric backbone, and in the case of secondary or tertiary amine groups, may be embedded within the backbone. Aminoalcohols can be linear or branched, saturated or unsaturated, aliphatic, alicyclic, aromatic, or heterocyclic. Examples of such aminoalcohols include those disclosed in U.S. application Ser. No. 10/859,557, the disclosure of which is incorporated by reference in its entirety.

[0020] Other polyahls, polyahl telechelics, and compounds suitable for forming such polyahls and polyahl telechelics, include polyacids, fatty polyacids, amino acids, hydroxyl acids, cyclic esters, cyclic amides, and cyclic ethers. Examples of such compounds include those disclosed in U.S. application Ser. No. 10/859,557, the disclosure of which is incorporated by reference in its entirety.

Isocyanate Reactants

[0021] Any one or blend of two or more isocyanate-functional compounds available to one of ordinary skill in the art may be suitable for use in compositions of the present disclosure. Isocyanate-functional compounds can be organic isocyanates in general, and may have an isocyanate functionality of about 1 (i.e., monoisocyanates), such as about 2 or greater (i.e., polyisocyanates). Polyisocyanates for use according to the disclosure can include monomers, dimers (such as uretdiones of identical polyisocyanates and isocyanate derivatives of dimer acids or dimer amines), trimers (such as isocyanurates of identical or different polyisocyanates,

isocyanate derivatives of trimer acids or trimer amines), tetramers, oligomers (of same or different monomers, or isocyanate derivatives of oligomer polyacids or oligomer polyamines), adducts (such as uretdiones of different polyisocyanates and isocyanate derivatives of adduct polyacids or adduct polyamines), polymers (such as isocyanate derivatives of polymer polyacids or polymer polyamines), polyisocyanate-terminated prepolymers, low-free-isocyanate prepolymers, quasi-prepolymers, isomers thereof, modified derivatives thereof, and combinations thereof. Structure of the isocyanate reactant can partially or fully be substituted, unsubstituted, saturated, unsaturated, hydrogenated, aliphatic, alicyclic, cyclic, polycyclic, aromatic, araliphatic, heteroaliphatic, and/or heterocyclic, and further include fatty polyisocyanates, sterically hindered polyisocyanates, and regioselective polyisocyanates.

[0022] Suitable polyisocyanates may have the generic structure of $R(NCO)_n$, where n is about 2-4; R comprises one or more linear or branched, substituted or unsubstituted, saturated or unsaturated moieties having about 2-60 carbon atoms, such as aliphatic moieties of about 4-30 or about 6-20 carbon atoms, cyclic or alicyclic moieties of about 6-40 or about 6-30 carbon atoms, aromatic or araliphatic moieties of about 6-30 or about 6-18 carbon atoms, and mixtures thereof. When multiple cyclic or aromatic moieties are present, linear and/or branched aliphatic hydrocarbon moieties having about 1-20 or about 1-10 carbon atoms can be present as spacers separating adjacent ring structures. The cyclic or aromatic moieties may be substituted at 2-, 3-, 4- and/or other available positions. Any available hydrogen atoms in the polyisocyanate can also be substituted. Substituent moieties include, but are not limited to, linear or branched aliphatic hydrocarbons; halogens; organic moieties having one or more heteroatoms such as N, O, S, P, and/or Si (e.g., cyano, amine, silyl, hydroxyl, acid, ether, ester, etc.); or a mixture (such as isomeric or racemic mixtures) thereof. Also included are, for example, oligoisocyanates and polyisocyanates which can be prepared from the diisocyanates or triisocyanates or mixtures thereof by coupling by means of urethane, allophanate, urea, biuret, uretdione, amide, isocyanurate, carbodiimide, uretonimine, oxadiazinetrione, and/or iminooxadiazinedione structures. Examples of such isocyanate-containing compounds and polymers include those disclosed in U.S. application Ser. No. 10/859,557, the disclosure of which is incorporated by reference in its entirety.

Curatives

[0023] Any and all of the compounds having two or more isocyanate-reactive functionalities as disclosed herein may be used as curatives to cure prepolymers into thermoplastic or thermoset compositions. These curatives can be polyamines, polyols, aminoalcohols, polyamine telechelics, and polyol telechelics, and aminoalcohol telechelics. To further improve the shear resistance of the resulting elastomers, trifunctional curatives, tetrafunctional curatives, and higher functionality curatives can be used to increase crosslink density. The curative may be modified with a freezing point depressing agent to create a curative blend having a slow onset of solidification and storage-stable pigment dispersion. Curatives comprising one or more ethylenic and/or acetylenic unsaturation moieties can be used to incorporate these moieties into the resulting material for subsequent crosslinking. Examples of such cura-

tives include those disclosed in U.S. application Ser. No. 10/859,557, the disclosure of which is incorporated by reference in its entirety.

[0024] Particularly suitable curatives are linear and cycloaliphatic amine curing agents including, but not limited to, ethylene diamine; 1,3-propylene diamine; 2-methyl-pentamethylene diamine; 1,3-pantanediamine; hexamethylene diamine; 2,2,4- and 2,4,4-trimethyl- 1,6-hexane diamine; polyoxyethylene diamines; polyoxypropylene diamines; (ethylene oxide capped)-polyoxypropylene ether diamines; polytetramethylene ether diamines; 1,4-diamino-cyclohexane; 1,3-diamino-cyclohexane; 1,2-diamino-cyclohexane; 1,12-dodecanediamine; 1-methyl-2,6-diamino-cyclohexane; 1,3- and 1,4-bis(methylamino)-cyclohexane; 1,2- and 1,4-bis (sec-butylamino)-cyclohexane; isophorone diamine; 4,4'-diamino-dicyclohexylmethane; 3,3'-dimethyl-4,4'-diamino-dicyclohexylmethane; 3,3'-diethyl-5,5'-dimethyl-4,4'-diamino-dicyclohexylmethane; 3,3'-dichloro-4,4'-diamino-dicyclohexane; 3,3'-diethyl-5,5'-dichloro-4,4'-diamino-dicyclohexylmethane; 3,3',5,5'-tetraethyl-4,4'-diamino-dicyclohexylmethane; 2,2'-dichloro-3,3',5,5'-tetraethyl-4,4'-diamino-dicyclohexylmethane; 3,3'-dichloro-4,4'-diamino-dicyclohexylmethane; 2,2',3,3'-tetrachloro-4,4'-diamino-dicyclohexylmethane; 3,3'-dichloro-2,2',6,6'-tetraethyl-4,4'-dicyclohexylmethane; 4,4'-bis(sec-butylamino)-dicyclohexylmethane (Clearlink® 1000); N,N'-dialkylamino-dicyclohexylmethane; 3,3'-dimethyl-4,4'-bis (sec-butylamino)-dicyclohexylmethane (Clearlink® 3000); N,N'-diisopropyl isophorone diamine (Jefflink® 754); N,N'-diethylmaleate-2-methyl-pentamethylene diamine (Desmophen® NH 1220); N,N'-di(ethylmaleate-amino)-dicyclohexylmethane (Desmophen® NH1420); N,N'-di(ethylmaleate-amino)-dimethyl-dicyclohexylmethane (Desmophen® 1520). Also suitable are polyamines such as diethylene triamine; dipropylene triamine; (propylene oxide)-based triamines; trimethylolpropane-based triamines; glycerin-based triamines; N-(2-aminoethyl)- 1,3-propylene diamine; triethylene tetramine; N,N'-bis-(3-aminopropyl) ethylene diamine; and mixtures thereof.

Polyurea Compositions

[0025] The compositions of the disclosure may comprise at least one polyurea formed from the well-known one-shot method or prepolymer method. In the latter, polyamine telechelic is reacted with excess polyisocyanate to form polyurea prepolymer, which is then reacted with curative to form the polyurea. Prepolymer to curative ratio can be as high as 1:0.9 or 1:0.95, such as when primary polyamine curatives are used, or as low as 1:1.1 or 1:1.05, such as 1:1.02, such as when secondary polyamine curatives (e.g., 4,4'-bis(sec-butylamino)-dicyclohexylmethane) are used. Curative includes polyamines, polyols, polyacids, aminoalcohols, aminoacids, and hydroxy acids, especially those disclosed herein, as well as epoxy-functional reactants, thio-containing reactants, and any other isocyanate-reactive compounds and materials. The polyurea composition can be castable, thermoplastic, thermoset, or millable.

[0026] The content of reactable isocyanate moieties in the polyurea prepolymer, expressed as % NCO by weight, can be manipulated to control such factors as curing rate, hardness of the resulting material, and the like. All else being the same, the hardness of the resulting material can increase as the % NCO of the prepolymer increases, and can be greater in polyamine cured compositions than in polyol cured compo-

sitions. The polyurea prepolymer can be low-melting (such as being fluid at about 125° C.) or fluid at ambient temperature. The % NCO by weight in the prepolymer can be less than about 30%, such as about 15%, about 11%, about 9%, about 7%, or even less, or at least about 2%, such as about 3% or about 4% or greater, or any percentage therebetween, such as about 5-11%, about 6-9.5%, about 3-9%, about 2.5-7.5%, or about 4-6.8%.

[0027] In forming the polyurea prepolymer, polyamine telechelics as disclosed herein can be used alone or in combination of two or more thereof to react with excess isocyanate. Prepolymers with higher % NCO (e.g., 14%) can be converted to prepolymers with lower % NCO (e.g., 10%) by further reacting with one or more other polyamines, polyols, polyamine telechelics, and/or polyol telechelics (e.g., polyamine polyamides, polyol polysiloxanes). The polyamine telechelic can have one amide linkage, two amide linkages, one or more segments having multiple amide linkages, or a polyamide backbone. When a plurality of amide linkages is present, one or more of them can conjoin consecutive repeating units or alternating repeating units. Polyurea prepolymers may contain a content of free isocyanate monomers by about 10% and up to about 20% of the total weight, which can be stripped down to about 1% or less, such as about 0.5% or less.

[0028] When forming a saturated prepolymer, such as for use in highly light-stable compositions, saturated polyisocyanates being aliphatic, alicyclic, and/or heteroaliphatic can be used alone or in combinations of two or more thereof. Araliphatic polyisocyanates, alone or in mixtures of two or more thereof, may also be used to form relatively light-stable materials. Without being bound to any particular theory, it is believed that the direct attachment of the NCO moieties to aliphatic side chains without conjugation with the aromatic rings prevents the araliphatic polyisocyanates from, or diminishes their ability in, forming extended conjugated double bonds, which may give rise to discoloration (e.g., yellowing). The sterically hindered polyisocyanates are useful in forming highly or relatively light-stable materials. Without being bound to any particular theory, it is believed that the steric hindrance around the N atom tends to rotate it out of plane, thereby reducing its absorbance of UV wavelengths and achieving desired light-stability. Moreover, one or more of the NCO groups in the sterically hindered polyisocyanates can be attached to tertiary or quaternary carbon atoms that are substantially free of C—H bonds, thus eliminating or reducing the occurrence of UV-induced oxidation at the carbon atoms, and in turn slowing degradation or discoloration. The saturated polyisocyanates, the araliphatic polyisocyanates, and the sterically hindered polyisocyanates may be used alone or in combinations of two or more thereof.

Polyurethane Compositions

[0029] The compositions of the disclosure may comprise at least one polyurethane, such as the reaction product of at least one polyurethane prepolymer and at least one curative, of which the polyurethane prepolymer is the reaction product of at least one polyol telechelic and at least one polyisocyanate. Prepolymer to curative ratio can be 1:0.9 to 1:1.1, such as 1:0.95, 1:1.05, or 1:1.02. One or more of the polyol telechelic, the polyisocyanate, and the curative can be chosen from those disclosed herein, can be saturated, and the resulting polyurethane can be saturated. Polyurethane prepolymers can have free isocyanate monomers by about 10% and up to about 20%

of the total weight, which can be stripped down to about 1% or less, such as about 0.5% or less.

[0030] The polyurethane composition can be castable, thermoplastic, thermoset, or millable. The % NCO by weight in the prepolymer can be less than about 30%, such as about 15%, about 11%, about 9%, about 7%, or even less, or at least about 2%, such as about 3% or about 4% or greater, or any percentage therebetween, such as about 5-11%, about 6-9.5%, about 3-9%, about 2.5-7.5%, or about 4-6.8%. In forming the polyurethane prepolymer, polyol telechelics as disclosed herein can be used alone or in combination of two or more thereof to react with excess isocyanate. Prepolymers with higher % NCO (e.g., 14%) can be converted to prepolymers with lower % NCO (e.g., 10%) by further reacting with one or more other polyamines, polyols, polyamine telechelics, and/or polyol telechelics (e.g., polyamine polyamides, polyol polysiloxanes). The polyol telechelic can have one or two amide linkages, one or more segments having multiple amide linkages, or a polyamide backbone. When a plurality of amide linkages is present, one or more of them can conjoin consecutive repeating units or alternating repeating units.

[0031] Crosslinkable polyurethanes can be formed from polyol telechelics, curatives, and stoichiometrically deficient amounts of polyisocyanate such as diisocyanate. Any one or more of the reactants can have one or more aliphatic, non-benzoid $>C=C<$ moieties for crosslinking. Such polyurethanes can have rubber elasticity and wear resistance and strength, and can be millable. Polyol telechelics of low crystallizability, such as those having linear or branched side chains and those formed by random copolymerization (e.g., polyol polyethers, polyol polyesters, polyol polyetheresters, and others as disclosed herein), can be used to form such polyurethanes. Non-limiting examples include polyethylene propylene adipate polyols, polyethylene butylene adipate polyols, polytetramethylene ether glycols (such as those having M_w of about 2,000), tetrahydrofuran (THF)-alkyl glycidyl ether random copolymers, and other polyol polyesters based on adipic acid and diols like ethanediol, butanediol, methylpropanediol, hexanediol. Polyol telechelics can be incorporated with ethylenic and/or acetylenic unsaturation moieties as disclosed above, such as by reacting them with α,β -ethylenically unsaturated carboxylic acids, and then crosslinked using vulcanizing agents as disclosed herein. Alternatively, the polyurethanes are substantially free of ethylenic

[0032] Formulations comprising such polyurethane materials and optional additives such as vulcanizing agents, fillers, plasticizers, light stabilizers, and others as disclosed herein, can form golf ball portions such as cover layers by extrusion, transfer molding, compression molding, and/or injection molding. Hemispherical cup can be preformed, such as by compression molding at ambient temperature. The cup halves can then be compression molded over subassemblies such as cores into inner cover layer or dimpled outer cover layer at elevated temperature (e.g., 320° F.) and under increased pressure (e.g., 800 psi), during which the formulation is crosslinked. After a period of time (e.g., 2.5 minutes) the molds are cooled (e.g., 10 minutes with tap water or 1 minute with tap water and then 4 minutes with chilled water) and the molded objects are released from the molds.

[0033] Properties of crosslinkable polyurethanes include Mooney viscosity at 100° C. of 40-70 (e.g., 50, 60, 65, or therebetween), tensile strength of 2,000-6,000 psi (e.g., 3,000 psi, 4,000 psi, 5,000 psi, or therebetween), tear strength of 300-600 lb/in (e.g., 400 lb/in, 500, lb/in, or therebetween),

brittle point of -70° F. or lower (e.g., -80° F., -90° F., or lower), material hardness of 25 Shore A to 60 Shore D (e.g., 55 Shore D), elongation at break of 100-700% (e.g., 300%, 400%, 500%, 600%, or therebetween), Bashore rebound of 40-70% (45%, 55%, or therebetween), and abrasion index (ASTM D-1630) of 300 or greater. Other crosslinkable compositions and components thereof are disclosed in U.S. Pat. Nos. 6,103,852 and 6,008,312, and in U.S. Publication No. 2002/0115813, which are incorporated herein by reference.

Poly(urethane-co-urea) Compositions

[0034] The compositions of the disclosure may comprise at least one poly(urethane-co-urea) formed from poly(urethane-co-urea) prepolymer and curative. Prepolymer to curative ratio can be as high as 1:0.9 or 1:0.95, such as when primary polyamine curatives are used, or as low as 1:1.1 or 1:1.05, such as 1:1.02, such as when secondary polyamine curatives are used. Curative includes polyamines, polyols, polyacids, aminoalcohols, aminoacids, and hydroxy acids, especially those disclosed herein, as well as epoxy-functional reactants, thio-containing reactants, and any other isocyanate-reactive compounds and materials.

[0035] Poly(urethane-co-urea) prepolymer refers to isocyanate-functional prepolymer having at least one urethane linkage and at least one urea linkage in the backbone. Such a prepolymer is distinct from polyurethane prepolymer, polyurea prepolymer, and blends thereof. The poly(urethane-co-urea) prepolymer can be formed by reacting excess isocyanate with a blend of at least one polyamine telechelic and at least one polyol telechelic. Molar ratio of polyol telechelic to polyamine telechelic in the blend can be about 0.5:1 to about 10:1, such as about 0.6:1 to about 7:1. Examples of blend include polyether polyols such as polyoxetetramethylene diol and polyether polyamines such as polyoxypropylene diamine.

[0036] The poly(urethane-co-urea) composition can be castable, thermoplastic, thermoset, or millable. The % NCO by weight in the prepolymer can be less than about 30%, such as about 15%, about 11%, about 9%, about 7%, or even less, or at least about 2%, such as about 3% or about 4% or greater, or any percentage therebetween, such as about 5-11%, about 6-9.5%, about 3-9%, about 2.5-7.5%, or about 4-6.8%. Prepolymers with higher % NCO (e.g., 14%) can be converted to prepolymers with lower % NCO (e.g., 10%) by further reacting with one or more other polyamines, polyols, polyamine telechelics, and/or polyol telechelics (e.g., polyamine polyamides, polyol polysiloxanes).

[0037] The poly(urethane-co-urea) prepolymer can be formed by reacting excess isocyanate with an aminoalcohol telechelic (or a blend of two or more thereof), optionally mixed with at least one polyamine reactant and/or at least one polyol reactant. The poly(urethane-co-urea) prepolymer can also be formed by reacting excess isocyanate with a polyamine reactant having at least one urethane linkage in the backbone, or with a polyol reactant having at least one urea linkage in the backbone. Polyamine reactants include any one or more polyamine telechelics and polyamines disclosed herein. Polyol reactants include any one or more polyol telechelics and polyols disclosed herein. The poly(urethane-co-urea) prepolymer can further be formed in situ from a mixture of at least one polyisocyanate, at least one cyclic compound such as cyclic ether, and at least one telechelic

chosen from polyamine telechelics, polyol telechelics, and aminoalcohol telechelics as disclosed herein.

Acid-Functionalized and Ionomerized Compositions

[0038] The reactive compositions of the present disclosure can be covalently incorporated or functionalized with ionic groups or precursor groups thereof, which can impart desirable properties to the resulting polymer materials. The term “ionic group or precursor group thereof” means a group either already in an anionic or cationic form or else, by neutralization with a reagent, readily converted to the anionic or cationic form respectively. The term “neutralize” as used herein for converting precursor groups to ionic groups refers not only to neutralization using true acids and bases but also includes quaternarization and ternarization. Illustrative of precursor anionic groups (and neutralized form) are acid groups like carboxylic group $-\text{COOH}(-\text{COO}^\ominus)$, sulfonic group $-\text{SO}_2\text{OH}(-\text{SO}_2\text{O}^\ominus)$, and phosphoric group (i.e., $=\text{POOH}$ or $=\text{POO}^\ominus$); illustrative of precursor cationic groups (and neutralized form) are $=\text{N}(=\text{N}-\oplus)$, $=\text{P}(=\text{P}-\oplus)$, and $=\text{S}(=\text{S}-\oplus)$.

[0039] The precursor groups of ionic groups can be incorporated into the isocyanate-reactive telechelic (including polyamine telechelics, polyol telechelics, and aminoalcohol telechelics), the isocyanate, and/or the curative before, during, or after the prepolymer formation or the curing reaction. They can be neutralized to corresponding ionic groups before, during, or after the prepolymer formation or the curing reaction. For example, the acid groups may be neutralized to form the corresponding carboxylate anion, sulfonate anion, and phosphate anion by treatment with inorganic or organic bases. Cationic precursor groups such as tertiary amine, phosphine, and sulfide groups can be neutralized by neutralization or quaternarization of the tertiary amine, or reacting the phosphine or sulfide with compounds capable of alkylating the phosphine or sulfide groups.

[0040] Suitable inorganic bases used for partial or total neutralization may include ammonia, oxides, hydroxides, carbonates, bicarbonates and acetates. Cation for the inorganic base can be ammonium or metal cations such as, without limitation, Group IA, IB, IIA, IIB, IIIA, IIIB, IVA, IVB, VA, VB, VIA, VIB, VIIB and VIIIB metal ions, which include, without limitation, lithium, sodium, potassium, magnesium, zinc, calcium, cobalt, nickel, tin, iron, copper, manganese, aluminum, tungsten, zirconium, titanium and hafnium. Suitable organic bases used for partial or full neutralization can be hindered organic tertiary amines such as tributylamine, triethylamine, tripropylamine, triethylene diamine, dimethyl cetylamine and similar compounds. Primary or secondary amines may be used, such as if the neutralization takes place after the polymer is formed, because the amine hydrogen can react with the isocyanate groups thereby interfering with the polyurea or polyurethane polymerization. One of ordinary skill in the art is aware of additional appropriate chemicals for neutralization.

[0041] At least a portion of the ionic groups can be covalently incorporated into the isocyanate-reactive telechelic before prepolymer formation. Suitable acid functional isocyanate-reactive telechelics may have any molecular weight, such as 1,500, an acid number (calculated by dividing acid equivalent weight to 56,100) of at least about 5, such as at least about 10, at least about 25, at least about 30, or at least about 50, may be about 420 or less, such as about 200 or less, about 150 or less, about 100 or less, and an acid functionality

of greater than 1, such as 1.4 or greater. In the case of polyol telechelics, the hydroxyl number of the polyols may be at least about 10, such as at least about 20, at least about 50, or at least about 65, may be about 840 or less, such as about 300 or less, about 200 or less, about 150 or less. The polyol telechelics may also have a hydroxyl functionality (average number of hydroxyl groups per polyol molecule) of greater than 1, about 2 or greater, like 1.8, and up to about 4. The acid functional telechelic can be liquid or wax at ambient temperature, and can have a viscosity at 60° C. of less than 5,000 cP, or 3,000 cP or less, such as 2,700 cP or less.

[0042] Ionic groups or precursor groups thereof may be incorporated into the monomers comprised in the telechelic. Monomers containing one or more ionic groups or precursor groups thereof can be, but are not limited to, cyclic ethers or diol monomers used to form polyether chains or segments, cyclic esters, diol monomers or polycarboxylic acids (such as lithium neutralized sulfonated isophthalic acid, tricarboxylic acids, or higher acids) used to form polyester chains or segments, cyclic amides, diamine monomers or polycarboxylic acids used to form polyamide chains or segments, cyclic siloxanes used to form polysiloxane chains or segments, (meth)acrylic acids used to form poly(meth)acrylic chains or segments, and fatty polyacids having three or more carboxylic acid functionalities and isocyanate-reactive derivatives thereof. Alternatively, the ionic groups or precursor groups thereof may be incorporated into the telechelic via the likes of addition or condensation reactions between suitable functional groups. For example, unsaturated carboxylic acids such as (meth)acrylic acids and unsaturated fatty acids as disclosed herein may react with unsaturation in the telechelic, thereby forming pendant carboxylic acids along the telechelic chain. Other methods of incorporating acid groups into the telechelic reactant are disclosed in the parent U.S. application Ser. No. 10/859,557.

Composition Additives

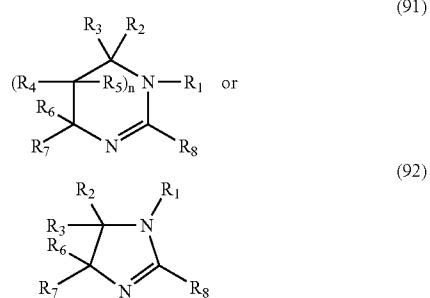
[0043] Additional materials may be incorporated into any of the reactive compositions of the present disclosure, or any one or more of the reactive subcomponents thereof. These additives include, but are not limited to, catalysts to alter the reaction rate, fillers to adjust density and/or modulus, processing aids or oils (such as reactive or non-reactive diluents) to affect rheological and/or mixing properties, reinforcing materials, impact modifiers, wetting agents, viscosity modifiers, release agents, internal and/or external plasticizers, compatibilizing agents, coupling agents, dispersing agents, crosslinking agents, defoaming agents, surfactants, lubricants, softening agents, coloring agents including pigments and dyes, optical brighteners, whitening agents, UV absorbers, hindered amine light stabilizers, blowing agents, foaming agents, and any other modifying agents known or available to one of ordinary skill in the art. One or more of these additives are used in amounts sufficient to achieve their respective purposes and desired effects. For example, wetting additives may be added to the modified curative blends of the disclosure to more effectively disperse pigments. Suitable wetting agents are available from Byk-Chemle and Crompton Corporation, among others.

a) Catalysts

[0044] One or more catalysts may be employed to alter the reaction rate between the prepolymer and the curative for the reactive compositions. In polyurethane compositions, positive catalysts (i.e., promoters) are typically used to speed up

the reaction between isocyanate groups and hydroxyl groups. In polyurea compositions, negative catalysts (i.e., inhibitors) may be used to slow down the typically fast reaction between isocyanate groups and amine groups. The same catalyst may be a promoter in a polyurethane system and an inhibitor in a polyurea system. Suitable catalysts include, but are not limited to, bismuth catalysts such as bismuth carboxylate (e.g., K-Kat® 348, K-Kat® XC-8203); zinc catalysts such as zinc octoate; cobalt catalysts such as cobalt (II) octoate; zirconium catalysts such as zirconium (IV) acetoacetone and zirconium (IV) acetylacetone-2,4-pentanedione (e.g., K-Kat® 4205, K-Kat® XC-6212, K-Kat® XC-9213, K-Kat® XC-A209); aluminum catalysts such as aluminum chelate complex (e.g., K-Kat® 5218); tin catalysts such as dibutyltin dilaurate (DABCO® T-12), dibutyltin diacetate (DABCO® T-1), dibutyltin maleate, dioctyltin dilaurate, dibutyltin di-2-ethylhexoate, tin(II) ethylhexoate, tin(II) laurate, tin(II) octoate, stannous oxalate, dibutyltin oxide, tin (II) chloride, tin (IV) chloride, dibutyltin dimethoxide (FASCAT®-4211), dibutyltin dibutoxide (FASCAT® 4214), dioctyltin diisooctylmercaptoacetate (FORMEZ® UL-29), dibutyltin diisooctylmercaptoacetate, dimethyltin diisooctylmercaptoacetate, dibutyltin dilaurylmercaptide, dioctyltin dilaurylmercaptide, dimethyltin dilaurylmercaptide, stannous octoate (DABCO® T-9), butyl stannoic acid, dimethyl-bis[11-oxonenedecyl]oxyl stannane (FORMEZ® UL-28), and 1,3-diacetoxytetrabutylstannoxane; titanium catalysts such as 2-ethylhexyl titanate, tetraisopropyl titanate, tetrabutyl titanate, and tetrakis-2-ethylhexyl titanate; amine catalysts such as triethylenediamine (DABCO® 33-LV), triethylamine, tributylamine, and N-methylmorpholine; organic acids such as acetic acid, adipic acid, azelaic acid, and oleic acid; delayed catalysts such as phenol-blocked 1,8-diaza-bicyclo(5.4.0)undecene-7 (Polycat™ SA-1/10), Polycat™ SA-1, Polycat™ SA-2, Polycat™ SA-102, Polycat™ 8154, Polycat™, and the like. These catalysts can be used alone or in combinations of two or more thereof.

[0045] Delayed action catalysts can also be used. These catalysts display their catalytic activity at a later time point in the reaction. They can be heat-activated, when external heating and/or internal heat from the exothermal reaction elevate the temperature of the reaction mixture to or above the activation temperature of the catalyst. One group of the delayed action catalyst is cyclic amidines, which can have a generic structure of:



where n=0 or 1; R₁ to R₇ are independently chosen from hydrogen and linear or branched aliphatic, alicyclic, araliphatic, and aromatic moieties, such as C₁-C₄ linear or branched alkyl, C₅-C₁₀ cycloalkyl, C₇-C₁₃ aralkyl, and

C₆-C₁₈ aryl moieties, or at least one of R₂/R₃, R₄/R₅, R₆/R₇, R₂/R₄ and R₂/R₆ is a C₁-C₅ alkylene moiety; R₈ is chosen from hydrogen and linear or branched aliphatic, alicyclic, araliphatic, and aromatic moieties having 1-36 carbon atoms, optionally substituted by one or more of OH, COOH, OR, NR₉R₁₀, or comprising at least one (up to about 10) of keto, amide, and ester moieties, or —CH(R)-[OCH₂—CH(R)]_p—H, where p is 1-40, R is chosen from linear or branched C₁-C₂₀ alkyl, cycloalkyl, aryl, and aralkyl moieties (e.g., C₁-C₁₅ alkyl, C₆-C₁₉ aryl), R₉ and R₁₀ are independently chosen from hydrogen and linear or branched aliphatic, alicyclic, araliphatic, and aromatic moieties (e.g., C₁-C₁₂ linear or branched alkyl, C₆-C₈ cycloalkyl) or R₉/R₁₀ is a C₄-C₆ alkylene moiety. Alternatively, these cyclic amidines can be used as blocking agent to block isocyanate functionalities in the prepolymer, allowing the isocyanate-blocked prepolymer to be thoroughly blended with the curative, and then de-blocking the prepolymer to enable the cure. This mechanism can be used in curing of polyurea composition to slow down reaction and extend potlife. These and other cyclic amidines as disclosed in U.S. Pat. No. 4,698,426 are incorporated herein by reference.

[0046] The catalyst can be added in an amount sufficient to catalyze the reaction of the components in the reactive mixture, such as about 0.001-5% by weight of the composition, about 0.005-1%, about 0.05% or greater, or about 0.5% or greater, preferably 0.75% or less, more preferably 0.5% or less. Use of low levels of tin catalysts, such as about 0-0.04%, may require high temperatures to achieve a suitable reaction rate, which can result in degradation of the prepolymer. Greater amounts of catalysts may allow reduction in process temperatures with comparable cure, and allow reduction in mixing speeds. Unconventionally high amounts of catalysts can be about 0.01-0.55%, about 0.05-0.4%, or about 0.1-0.25%.

[0047] In one example, a negative catalyst or a blend of two or more negative catalysts is used in a composition having an isocyanate-containing prepolymer and a polyamine curative, in which the catalyst and the polyamine forms an intermediate complex. The intermediate complex reduces the reactivity between the polyamine and the prepolymer through steric hindrance and/or prolonged rearrangement of the complex. The negative catalyst is preferably a tin compound used in an amount of from 0.01 wt % to 1.00 wt %, or from 0.05 wt % to 0.75 wt %, or from 0.1 wt % to 0.5 wt %, based on the total polymer weight. In a particular embodiment, the polyisocyanate used to form the prepolymer is a linear- or cycloaliphatic-based polyisocyanate selected from 1,4-tetramethylene diisocyanate; 1,5-pentamethylene diisocyanate; 2-methyl-1,5-pentamethylene diisocyanate; 1,6-hexamethylene diisocyanate and isomers thereof; 2,2,4- and 2,4,4-trimethylhexamethylene diisocyanates; 1,7-heptamethylene diisocyanate and isomers thereof; 1,8-octamethylene diisocyanate and isomers thereof; 1,9-novamethylene diisocyanate and isomers thereof; 1,10-decamethylene diisocyanate and isomers thereof; 1,12-dodecane diisocyanate and isomers thereof; 1,3-cyclobutane diisocyanate; 1,2-, 1,3-, and 1,4-cyclohexane diisocyanates; 2,4- and 2,6-methylcyclohexane diisocyanates; isophorone diisocyanate; isocyanatomethylcyclohexane isocyanate; isocyanatoethylcyclohexane isocyanate; 1,2-, 1,3-, 1,4-bis(isocyanatomethyl)cyclohexane; 1,3-bis(1-isocyanato-1-methylethyl)-cyclohexane; 4,4'-dicyclohexylmethane diisocyanate; 2,4'- and 4,4'-dicyclohexane diisocyanates; 2,4'- and 4,4'-bis

(isocyanatomethyl)dicyclohexanes; uretdiones of hexamethylene diisocyanates; trimerized isocyanurates of hexamethylene diisocyanates; and mixtures thereof. The composition may have a gel time of 60 seconds or greater, preferably 80 seconds or greater, more preferably 100 seconds or greater, most preferably 120 seconds or greater.

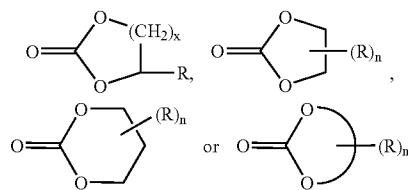
Diluents

[0048] As used herein, the term "diluent" refers to any compound or composition that can reduce viscosity, reduce reaction exotherm, and/or impart or enhance properties such as flame retardancy, processability, compatibility, and moisture resistance, without adversely affecting the qualitative or physical properties of the resulting polymer. Diluents are distinct from solvents in that diluents remain within the polymer post-cure, while solvents are evaporated off post-cure. Diluent can be linear or branched, aliphatic, cyclic (e.g., alicyclic, aromatic, or araliphatic), saturated or unsaturated, substituted or unsubstituted, halogenated or halogen-free, and/or hydrophobic or hydrophilic, and include within its scope plasticizer materials. Diluents can be reactive or substantially unreactive. Diluent can be substantially water insoluble. Diluent can be added at any time before, during, or after prepolymer preparation, e.g., separately or as a mixture with one or more reaction components prior to prepolymer preparation, in amount sufficient to reduce the viscosity of the prepolymer to about 1,000-4,000 cP at temperatures of about 125° C. or less. Diluents can have a viscosity of about 50 cP or less at 25° C. Diluents can have a boiling point of greater than 90° C.

[0049] The diluent can be used individually or in blends of two or more thereof, and can comprise at least about 0.05% by weight of the prepolymer or the total reactive composition, such as 2%, 3%, 4%, 5%, 6%, 10%, 15%, 18%, 20%, 35%, 50%, 60%, 70%, or greater or any amount therebetween. The amount of the diluent is preferably 0.05% to 12%, more preferably 0.1% to 8%, most preferably 0.5% to 6%. In one example, the diluent or a blend thereof is used a composition (preferably a castable composition) having a prepolymer (preferably a polyurea prepolymer formed from a telechelic polyamine and a polyisocyanate) and a curative in a sufficient amount such that the composition has a processing viscosity of 1,000 cP to 4,000 cP. In another example, the telechelic polyamine has a number average molecular weight of 1,500 to 5,000, the polyisocyanate is an alicyclic diisocyanate, and the curative is an alicyclic secondary diamine (e.g., 4,4'-bis (sec-butylamino)-dicyclohexylmethane). Suitable diluent can be chosen according to parameters such as compatibility with the composition and desired properties of the final polymer. For example, ester diluents tend to be compatible with polyester-based prepolymers. Reactive diluents can react with one or more functionalities of one or more ingredients in the composition. For example, epoxy and carbonate diluents can react with ingredients having amine groups and/or hydroxyl groups, while ethylenically unsaturated diluents can react with ingredients having ethylenic unsaturation.

[0050] Suitable diluents include those described in U.S. Pat. Nos. 3,773,697, 5,929,153, 3,929,700 and 3,936,410, and 4,343,925 (column 9, line 37 to column 13, line 62), the disclosures of which are incorporated herein by reference. Non-limiting examples of diluents include phosphates, esters, epoxies, carbonates, ethers, alkoxylated alcohols, fatty telechelics, such as:

[0051] a) cyclic carbonates which can be substituted (with groups such as alkyl, hydroxyalkyl, halogen, etc.) or unsubstituted, and can be prepared such as reacting a compound having an oxirane group (e.g., cyclic ether such as propylene oxide) with carbon dioxide, having a structure of:



where x is about 1-9, such as 1 or 2; n is 1 to about 40, such as 1, 2, 3, or even integers of about 4-20, like 4 or 6; R is the same or different moieties independently chosen from hydrogen, linear or branched hydrocarbon groups (such as alkyl, aryl, cyclic, saturated, or unsaturated) having about 1-20 carbon atoms, such as about 1-18, about 4-9, about 1-6, or about 1, 2, or 3 carbon atoms, linear or branched hydroxyalkyl groups having about 1-20 carbon atoms, such as about 1-18, about 1-6, or about 1-3 carbon atoms, linear or branched alkoxyalkylene or polyalkoxyalkylene, linear or branched haloalkyl groups having about 1-20 carbon atoms, such as chloromethyl, linear or branched $-\text{C}_m\text{H}_{2m+1}$ or $-\text{C}_m\text{H}_{2m}\text{OH}$ where m is about 1-8, and linear or branched $-(\text{CH}_2)_m\text{H}$ or $-(\text{CH}_2)_m\text{OH}$ where m is about 1-2, linear or branched alkoxy groups such as methoxyl and ethoxyl, aryloxy groups such as phenoxy, including 5-membered cyclic carbonates such as ethylene carbonate, propylene carbonate, butylene carbonate, isobutylene carbonate, styrene carbonate, phenylethylene carbonate, butyl soyate carbonate, butyl linseed carbonate, and glycerin carbonate, fatty acid carbonates like oleic acid 8,9-carbonate, succinic acid glyceryl carbonate monoester, glutaric acid glyceryl carbonate monoester, 9,10-dihydroxystearic acid carbonate, and 6-membered cyclic carbonates such as cyclic trimethylolpropane carbonate and those disclosed in U.S. Pat. Nos. 4,501,905 and 4,440,937, which are incorporated herein by reference, with suitable examples available under the tradename Jeffsol® from Huntsman Corporation, Austin, Tex.;

[0052] b) phosphorus-containing compounds including phosphites (e.g., triaryl phosphites like triphenyl- and tritolyl phosphite, dialkyl phosphites like diisopropyl-, dibutyl-, bis(2-ethylhexyl)-, bis(tridecyl)-, and dioleyl phosphites, trialkyl phosphites like tris(2-ethylhexyl)-, triisopropyl-, tributyl-, tris(2-chloroethyl)-, and triisoctyl phosphites, cyclic phosphate esters and cyclic phosphonate esters (e.g., those disclosed in U.S. Pat. No. 5,030,674, column 3, line 63 to column 4, line 55, which is incorporated by reference herein), and phosphate esters (e.g., trialkyl phosphates like triethyl-, tributyl-, tris(2-ethylhexyl)-, tricresyl-, trioctyl-, 2-ethylhexyl diphenyl phosphate, isodecyldiphenyl phosphate, cresyldiphenyl phosphate, p-t-butylphenyldiphenyl phosphate, triphenyl phosphate, trixylyl phosphate, trixylenyl phosphate, phenyldicresyl phosphate, xylenyldicresyl phosphate, cresyldixylenyl phosphate, tributoxy ethylphosphate, chloroalkyldiphosphate esters, trichloroethyl phosphate, and tris(isopropyl)chlorophosphate, chlorinated biphenyl phosphate, chlorinated diphosphate, phosphonates such as chlorinated polyphosphonate, alkoxylated fatty alcohol phosphate esters such as oleth-2 phosphate, oleth-3 phosphate,

oleth-4 phosphate, oleth-10 phosphate, oleth-20 phosphate, ceteth-8 phosphate, ceteareth-5 phosphate, ceteareth-10 phosphate, PPG ceteth-10 phosphate, some of which are available from Albemarle Corporation of Baton Rouge, La., Great Lakes Chemical Corporation of West Lafayette, Ind., and Rhodia Inc. of Cranbury, N.J.;

[0053] c) epoxies such as glycidyl ethers, butylepoxy stearate, octylepoxy stearate, epoxybutyl oleate, epoxidized butyl oleate, epoxidized soybean oil, epoxidized linseed oil, epoxidized alkyl oil, epoxidized alkyl oil alcohol ester, mono-, di-, and polyglycidyl ethers of castor oil and other fatty polyols and fatty polyol telechelics like those disclosed herein, mono-, di-, and polyglycidyl esters of fatty polyacids and dimer acids like those disclosed herein, such as Heloxy® and Cardura® by Resolution Performance Products of Houston, Tex.;

[0054] d) alkyl and/or aryl esters, diesters, triesters, dialkyl or diaryl diesters, trialkyl or triaryl triesters of such acids and anhydrides as acetic acid, hexanoic acid, adipic acid, azelaic acid, benzoic acid, citric acid, dimer acids, fumaric acid, isobutyric acid, isophthalic acid, lauric acid, linoleic acid, maleic acid, maleic anhydride, melissic acid, myristic acid, oleic acid, palmitic acid, phthalic acid, ricinoleic acid, sebacic acid, stearic acid, succinic acid, 1,2-benzenedicarboxylic acid, and the like, and mixtures thereof, where the alkyl group can independently be linear or branched alkyl having about 1-20 carbon atoms, $H_3CO(CO)(CH_2)_n(CO)OCH_3$ where n is an integer of about 1-10 or about 8-20, such as methyl 2-ethylhexanoate, butyl acetate, methyl laurate, methyl linoleate, isopropyl myristate, butyl oleate, methyl palmitate, butyl ricinoleate, methyl stearate, dibenzoate esters, di(aminobenoate) esters, 2-ethylhexylbenzoate, dimethyl adipate, diisopropyl adipate, dibutyl adipate, di-2-ethylhexyl adipate, dicapryl adipate, di-n-decyl adipate, and diisodecyl adipate, polypropylene adipate, heptyl nonyl adipate, dimethyl azelate, dimethyl sebacate, dibutyl sebacate, di-2-ethylhexyl sebacate, dimethyl glutarate, dimethyl succinate, diethyl succinate, dibutyl fumarate, dioctyl fumarate, di-n-butyl maleate, butyl octyl phthalate, butylcyclohexyl phthalate, butylauryl phthalate, butylcoconutalkyl phthalate, heptylnonyl phthalate, octyldecanoyl phthalate, octyldecyl phthalate, isoctylisodecyl phthalate, dimethyl phthalate, diethyl phthalate, di-n-butyl phthalate, diisobutyl phthalate, di-2-ethylhexyl phthalate, dihexyl phthalate, bis(3,5,5-trimethylhexyl) phthalate, dicyclohexyl phthalate, diheptyl phthalate, di-n-octyl phthalate, diisooctyl phthalate, dinonyl phthalate, diisononyl phthalate, diisodecyl phthalate, dicapryl phthalate, dilauryl phthalate, diundecyl phthalate, ditridecyl phthalate, diphenyl phthalate, dimethoxyethyl phthalate, butylbenzyl phthalate, butylphenylmethyl phthalate, C_7/C_9 alkylbenzyl phthalate, isodecylbenzyl phthalate, texanolbenzyl phthalate, 7-(2,6,6,8-tetramethyl-4-oxa-3-oxo-nonyl)benzyl phthalate, bis(diethyleneglycolmonomethylether) phthalate, dimethylglycol phthalate, triethyl citrate, acetyltriethyl citrate, tributyl citrate, acetyltributyl citrate, tricapryl trimellitate, trioctyl trimellitate, triisooctyl trimellitate, tridecyl trimellitate, trisodecyl trimellitate, heptylnonyl trimellitate, methylphthalyl ethylene glycolate, ethylphthalyl ethylene glycolate, butylphthalyl ethylene glycolate, glycerol triacetate, benzphenol, and mixtures thereof (e.g., about 20% by weight of dimethyl succinate, 21% by weight of dimethyl adipate and about 59% by weight of dimethyl glutarate);

[0055] e) mono-, di-, or polyesters of fatty acids having about 8 or more carbon atoms with di-, tri-, or polyhydric

alcohols, such as glycerin monostearate, glycerin 12-hydroxy stearate, glycerin distearate, diglycerin monostearate, tetraglycerin monostearate, glycerin monolaurate, diglycerin monolaurate, and tetraglycerin monolaurate;

[0056] f) diesters of α,ω -diols where the acid can be linear or branched chain alcanoic acid having about 1-6 carbon atoms or aromatic acid and the diol can be linear or branched chain aliphatic diol, such as diethylene glycol dibenzoate, dipropylene glycol dibenzoate, polyethylene glycol dibenzoate, 2,2,4-trimethyl-1,3-pentanediol diisobutyrate (TXIB available from Eastman Chemical Company of Kingsport, Tenn.) and diethylene glycol dibenzoate, 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate benzoate;

[0057] g) mono- and di-alkyl (such as C_1-C_6) glycol ethers of alkylene and polyalkylene glycols, and analogs of such glycol ethers as some of the polyol telechelics disclosed herein, such as monomethyl diethylene glycol, monoethyl dipropylene glycol, and monomethyltripropylene glycol;

[0058] h) alkoxylated alcohols, such as nonyl phenols alkoxylated with about 1-50 (such as about 7-12) moles of an alkoxylating agent or mixture of alkoxylating agents having about 1-6 (such as about 2-4) carbon atoms, alkoxylated bisphenol A like ethoxylated bisphenol A, and propoxylated trimethylolpropane, some of which are available from Stepan Company of Northfield, Ill.;

[0059] i) fatty telechelics such as fatty polyamine telechelics and fatty polyol telechelics disclosed herein, some of which can be liquid at ambient temperature, like castor oil, soy and linseed oils;

[0060] j) compounds and mixtures having ethylenic unsaturation, such as polyesters of unsaturated carboxylic acids (e.g., tripropylene glycol diacrylate, Bisphenol A diglycidylether diacrylate, 1,6-Hexanediol diacrylate, 1,4-butanediol dimethacrylate, ethyleneglycol dimethacrylate, polyethylene glycol dimethacrylate, diethylene glycol dimethacrylate, urethane dimethacrylate, tetraethylene glycol dimethacrylate, triethylene glycol dimethacrylate, trimethylolpropane trimethacrylate, pentaerythritol triacrylate, and trimethylolpropane triacrylate), bismaleimides (e.g., N,N' -m-phenylenedimaleimide), polyamides of unsaturated carboxylic acids, esteramides of unsaturated carboxylic acids, allyl esters of cyanurates (e.g., triallyl cyanurate), allyl esters of isocyanurates (e.g., triallyl isocyanurate), allyl esters of aromatic acids (e.g., triallyl trimaleate and triallyl trimellitate), liquid vinyl polydienes (e.g., liquid vinyl polybutadiene homopolymers and copolymers having molecular weight of about 1,000 to about 5,000, such as about 1,800 to about 4,000, or about 2,000 to about 3,500, like 90% high vinyl polybutadiene having a molecular weight of about 3,200, 70% high vinyl 1,2-polybutadiene having a molecular weight of about 2,400, and 70% high vinyl poly(butadiene-styrene) copolymer having a molecular weight of about 2,400), mono- and polyunsaturated polycarboxylic acids and anhydrides, monoesters, polyesters, monoamides, polyamides, esteramides, and polyesteramides thereof (e.g., citraconic acid, itaconic acid, fumaric acid, maleic acid, mesaconic acid, aconitic acid, maleic anhydride, itaconic anhydride, citraconic anhydride, poly(meth)acrylic acid, polyitaconic acid, copolymers of (meth)acrylic acid and maleic acid, copolymers of (meth)acrylic acid and styrene, and fatty acids having a C_6 or longer chain, such as hexadecenedioic acid, octadecenedioic acid, vinyl-tetradecenedioic acid, eicosenedioic acid, dimethyl-eicosenedioic acid, 8-vinyl-10-octadecenedioic acid, anhydrides thereof, methyl, ethyl, and other linear or

branched alkyl esters thereof, amides thereof, esteramides thereof, and mixtures thereof), unsaturated oils, polyester diol reaction product of o-phthalic acid and diethylene glycol, and mixtures thereof;

[0061] k) other miscellaneous compounds including alkoxy alkyl esters such as methoxy propylacetate and ethoxy propylacetate, pyrrolidones such as N-methyl-2-pyrrolidone and N-vinyl-pyrrolidone, monohydroxylated polybutadienes, silicones such as dimethicone copolyol esters, dimethiconol esters, and silicone carboxylates, aromatic petroleum condensate, partially hydrogenated terphenyls, guerbet esters, cyclic esters, cyclic ethers, and/or cyclic amides such as those disclosed herein; and

[0062] l) mixtures of two or more compounds chosen from a)-k).

Fillers

[0063] As used herein, the term "filler" refers to any compound or composition or mixture thereof that can be used to vary certain properties of selected portions of the golf ball, including density or specific gravity, flexural modulus, tensile modulus, tear strength, moment of inertia, hardness, abrasion resistance, weatherability, volume, weight, etc. The fillers can be in the forms of nano-scale or micro-scale powders, fibers, filaments, flakes, platelets, whiskers, wires, tubes, or particulates for homogenous dispersion. Suitable fillers for golf balls may be solid or hollow, and include, for example, metal (or metal alloy) powder, metal oxide and salts, ceramics, particulates, carbonaceous materials, polymeric materials, glass microspheres, and the like or blends thereof. Non-limiting examples of metal (or metal alloy) powders include bismuth, brass, bronze, cobalt, copper, inconel, iron, molybdenum, nickel, stainless steel, titanium, aluminum, tungsten, beryllium, zinc, magnesium, manganese, and tin. Non-limiting examples of metal oxides and salts include zinc oxide, iron oxide, aluminum oxide, titanium dioxide, magnesium oxide, zirconium oxide, tungsten trioxide, zirconium oxide, tungsten carbide, tungsten oxide, tin oxide, zinc sulfide, zinc sulfate, zinc carbonate, barium sulfate, barium carbonate, calcium carbonate, calcium metasilicate, magnesium carbonate, and silicates. Non-limiting examples of carbonaceous materials include graphite and carbon black. Examples of other useful fillers include precipitated hydrated silica, boron, clay, talc, glass fibers, aramid fibers, mica, diatomaceous earth, regrind (typically recycled core material mixed and ground to 30 mesh particle size), high Mooney viscosity rubber regrind, and mixtures thereof. Examples of polymeric materials include, but are not limited to, hollow spheres or microspheres of chemically or physically foamed thermoplastic or thermosetting polymers, such as epoxies, urethanes, polyesters, nucleated reaction injection molded polyurethanes or polyureas.

[0064] The selection of fillers is in part dependent upon the type of golf ball desired, i.e., one-piece, two-piece, multi-component, or wound. Fillers may be used to modify the weight of any portion of the golf ball. The filler can be inorganic, having a density of greater than 4 g/cc, and can be present in amounts of 5-65 wt. % of the polymer components included in the golf ball portion.

[0065] Other additives, such as physical or chemical blowing or foaming agents, light stabilizers, freezing point depressants, vulcanizing agents (e.g., radical initiators, polyisocyanates, co-crosslinking agent, curatives comprising ethylenic and/or acetylenic unsaturation moieties, cis-to-trans cata-

lysts, organosulfur compounds, and/or processing aids), moisture scavengers, and fragrance or masking components include those disclosed in the parent U.S. application Ser. No. 10/859,557.

[0066] The compositions of the disclosure can be used in amounts of 1-100%, such as 10-90% or 10-75%, to form any portion of the golf ball, optionally in blend with one or more other materials being present in amounts of 1-95%, 10-90%, or 25-90%. The percentages are based on the weight of the portion in question. Conventional materials for golf ball cover, intermediate layer, and core suitable as the other materials include those disclosed in the parent U.S. application Ser. No. 10/859,557.

Core Compositions

[0067] The cores of the golf balls formed according to the disclosure may be solid, semi-solid, hollow, fluid-filled, gas-filled, powder-filled, one-piece or multi-component cores. The term "semi-solid" as used herein refers to a paste, a gel, or the like. Any core material known to one of ordinary skill in that art is suitable for use in the golf balls of the disclosure. Suitable core materials include thermoset materials, such as rubber, styrene butadiene, polybutadiene, isoprene, polyisoprene, trans-isoprene, as well as thermoplastics such as ionomer resins, polyamides, and polyesters, and thermoplastic or thermoset polyurethane or polyurea elastomers. As mentioned above, the compositions of the present disclosure may be incorporated into any portion of the golf ball, including the core. For example, an inner core center or a core layer may comprise at least one of the reactive compositions disclosed herein.

[0068] The golf ball core can comprise one or more materials chosen from base rubber (natural, synthetic, or a combination thereof, such as polybutadiene), crosslinking initiator (such as dialkyl peroxide), co-crosslinking agent (such as those having di- or polyunsaturation and at least one readily extractable hydrogen in the α position to the unsaturated bonds), filler, cis-to-trans catalyst, organosulfur compound, among others. Choices for these materials are known to one skilled in the art, such as those disclosed in co-pending and co-assigned U.S. Patent Publication No. 2003/0119989, bearing Ser. No. 10/190,705, the disclosure of which is incorporated by reference herein. The core compositions can be used to form any other portions of the golf ball, such as one or more of the intermediate layers and cover layers.

Intermediate Layer Compositions

[0069] When the golf ball comprises at least one intermediate layer, such as one disposed between the cover and the core, or an inner cover layer or outer core layer, i.e., any layer(s) disposed between the inner core and the outer cover of the golf ball, this layer can be formed from any one or more thermoplastic and thermosetting materials known to those of ordinary skill. These materials can be any and all of those disclosed in the parent U.S. application Ser. No. 10/859,557.

[0070] The intermediate layer may include homopolymers or copolymers of ethylene, propylene, butylene, butene, and/or hexene, optionally incorporating functional monomers such as acrylic and methacrylic acid, optionally being fully or partially neutralized ionomer resins and their blends. The acid copolymers can be E/X or E/X/Y copolymers where E is ethylene, X is α,β -ethylenically unsaturated carboxylic acid or a combination of two or more thereof, such as having about

3-8 carbon atoms (e.g., acrylic acid and/or methacrylic acid), and Y is a softening co-monomer, such as alkyl (meth)acrylate where the alkyl group can be linear or branched and have about 1-8 carbon atoms (e.g., n-butyl). By "softening," it is meant that the crystallinity is disrupted (the polymer is made less crystalline). X can be at least about 2 wt. % of the copolymer, such as 2-30, 3-30, 4-20, 4-25, 5-20, or 5-20 wt. % of the polymer, and Y can be present in 0-30, 3-25, 10-23, 17-40, 20-40, or 24-35 wt. % of the acid copolymer.

[0071] Soft, resilient ionomers included in this disclosure can be partially neutralized ethylene/(meth) acrylic acid /butyl (meth) acrylate copolymers having a melt index (MI) and level of neutralization that results in a melt-processible polymer that has useful physical properties. The copolymers are at least partially neutralized. At least 40%, or at least 55%, such as about 70% or about 80% of the acid moiety of the acid copolymer can be neutralized by one or more alkali metal, transition metal, or alkaline earth metal cations, such as lithium, sodium, potassium, magnesium, calcium, barium, or zinc, or a combination of such cations.

[0072] Soft, resilient, thermoplastic, "modified" ionomers are also exemplary materials for use in any one or more golf ball portions present in any construction, such as the inner center, inner core layer, intermediate core layer, outer core layer, intermediate layer, inner cover layer, intermediate cover layer, outer cover layer, and the like and equivalents thereof. The "modified" ionomer can comprise a melt blend of (a) the acid copolymers or the melt processible ionomers made therefrom as described above and (b) one or more organic acid(s) or salt(s) thereof, wherein greater than 80%, or greater than 90%, even 100% of all the acid of (a) and of (b) can be neutralized by one or more cations. Amount of cations in excess of the amount required to neutralize 100% of the acid in (a) and (b) can be used to neutralize the acid in (a) and (b). Blends with fatty acids or fatty acid salts, including those disclosed in the parent U.S. application Ser. No. 10/859,557, can be used.

[0073] The acid copolymers can be "direct" acid copolymers (containing high levels of softening monomers). As noted above, the copolymers can be partially, highly, or fully neutralized, such as at least about 40%, 45%, 50%, 55%, 70, 80%, 90%, or 100% neutralized. The MI of the acid copolymer should be sufficiently high so that the resulting neutralized resin has a measurable MI in accord with ASTM D-1238, condition E, at 190° C., using a 2160 gram weight, such as at least about 0.1 g/10 min, at least about 0.5 g/10 min, or about 1 g/10 min or greater. In highly neutralized acid copolymer, the MI of the acid copolymer base resin can be at least about 20 g/10 min, at least 40 g/10 min, at least 75 g/10 min, at least 100 g/10 min, or at least 150 g/10 min.

[0074] Specific acid-copolymers include ethylene/(meth) acrylic acid/n-butyl (meth) acrylate, ethylene/(meth) acrylic acid/iso-butyl (meth) acrylate, ethylene/(meth) acrylic acid/methyl (meth) acrylate, and ethylene/(meth) acrylic acid/ethyl (meth) acrylate terpolymers. The organic acids and salts thereof employed can be aliphatic, mono-functional (saturated, mono-unsaturated, or poly-unsaturated) organic acids, including those having fewer than 36 carbon atoms, such as 6-26, 6-18, or 6-12 carbon atoms. The salts may be any of a wide variety, including the barium, lithium, sodium, zinc, bismuth, potassium, strontium, magnesium and calcium salts of the organic acids. Non-limiting examples of the organic acids include caproic acid, caprylic acid, capric acid, lauric acid, stearic acid, behenic acid, erucic acid, oleic acid, and

linoleic acid. Other fatty acids and salts thereof include any and all of those disclosed herein above, such as fatty polyacids and polymerized fatty polyacids (e.g., dimer diacids) and salts thereof. Partial esters of polyacids (i.e., having at least one un-esterified acid group) and salts thereof are also useful. When mono- and/or poly-unsaturated organic acids and/or salts thereof are used, the ionomer composition can be crosslinked into a thermoset material using reactants known to one skilled in the art, such as peroxide and/or sulfur initiators, some of which are disclosed herein. Alternatively, radiations such as electron beam radiation and others disclosed herein can be used to crosslink the ionomer composition. Optional additives include acid copolymer wax (e.g., Allied wax AC 143 believed to be an ethylene/16-18% acrylic acid copolymer with a number average molecular weight of 2,040), which assist in preventing reaction between the filler materials (e.g., ZnO) and the acid moiety in the ethylene copolymer, TiO₂ (a whitening agent), optical brighteners, etc.

[0075] Ionomers may be blended with conventional ionomeric copolymers and terpolymers, and non-ionomeric thermoplastic resins. The non-ionomeric thermoplastic resins include, without limit, thermoplastic elastomers such as polyurethane, poly-ether-ester, poly-amide-ether, polyether-urea, PEBAX (a family of block copolymers based on polyether-block-amide, commercially supplied by Atochem), styrene-butadiene-styrene (SBS) block copolymers, styrene(ethylene-butylene)-styrene block copolymers, etc., poly amide (oligomeric and polymeric), polyesters, polyolefins including PE, PP, E/P copolymers, etc., ethylene copolymers with various comonomers, such as vinyl acetate, (meth)acrylates, (meth)acrylic acid, epoxy-functionalized monomer, CO, etc., functionalized polymers with maleic anhydride grafting, epoxidization etc., elastomers such as EPDM, metallocene catalyzed PE and copolymer, ground up powders of the thermoset elastomers, etc. Such thermoplastic blends can comprise about 1% to about 99% by weight of a first thermoplastic and about 99% to about 1% by weight of a second thermoplastic.

Cover Compositions

[0076] Obviously, one or more of the cover layers may be formed, at least in part, from the compositions of the present disclosure. The cover layers include outer cover layer, inner cover layer, and any intermediate layer disposed between the inner and outer cover layers. The cover compositions can include one or more of the polyurethane prepolymers, polyurea prepolymers, poly(urethane-co-urea) prepolymers, polyisocyanates, curatives, and additives. Other materials useful in cover composition blends include those disclosed herein for the core and the intermediate layer.

Golf Ball Constructions

[0077] The golf ball can have any construction, including, but not limited to, one-piece, two-piece, three-piece, four-piece, and other multi-piece designs. The golf ball can have a single core, a 2-layer core, a 3-layer core, a 4-layer core, a 5-layer core, a 6-layer core, a multi-layer core, a single cover, a 2-layer cover, a 3-layer cover, a 4-layer cover, a 5-layer cover, a 6-layer cover, a multi-layer cover, a multi-layer cover, and/or one or more intermediate layers. The compositions of the disclosure may be used in any one or more of these golf

ball portions, each of which may have a single-layer or multi-layer structure. As used herein, the term "multi-layer" means at least two layers.

[0078] Any of these portions can be one of a continuous layer, a discontinuous layer, a wound layer, a molded layer, a lattice network layer, a web or net, an adhesion or coupling layer, a barrier layer, a layer of uniformed or non-uniformed thickness, a layer having a plurality of discrete elements such as islands or protrusions, a solid layer, a metallic layer, a liquid-filled layer, a gel-filled portion, a powder-filled portion, a gas-filled layer, a hollow portion, or a foamed layer.

[0079] In addition, when the golf ball of the present disclosure includes an intermediate layer, this layer may be incorporated with a single or multilayer cover, a single or multi-piece core, with both a single layer cover and core, or with both a multilayer cover and a multilayer core. The intermediate layer may be an inner cover layer or outer core layer, or any other layer(s) disposed between the inner core and the outer cover of a golf ball. As with the core, the intermediate layer may also include a plurality of layers. It will be appreciated that any number or type of intermediate layers may be used, as desired.

Methods of Forming Layers

[0080] The golf balls of the disclosure may be formed using a variety of application techniques such as compression molding, flip molding, injection molding, retractable pin injection molding, reaction injection molding (RIM), liquid injection molding (LIM), casting, vacuum forming, powder coating, flow coating, spin coating, dipping, spraying, and the like. Conventionally, compression molding and injection molding are applied to thermoplastic materials, whereas RIM, liquid injection molding, and casting are employed on thermoset materials. These and other manufacture methods are disclosed in U.S. Pat. Nos. 6,207,784 and 5,484,870, the disclosures of which are incorporated herein by reference.

[0081] The compositions of the disclosure may be formed over the core using a combination of casting and compression molding. For example, U.S. Pat. No. 5,733,428, the disclosure of which is hereby incorporated by reference, discloses a suitable method for forming a polyurethane cover on a golf ball core. Because this method relates to the use of both casting thermosetting and thermoplastic material as the golf ball cover, wherein the cover is formed around the core by mixing and introducing the material in mold halves, other reactive liquid compositions such as polyurea compositions may also be used employing the same casting process. Once the polyurea composition is mixed, an exothermic reaction commences and continues until the material is solidified around the core. Viscosity can be measured over time, so that the subsequent steps of filling each mold half, introducing the core into one half and closing the mold can be timed in order to center the core and achieve overall uniformity. A suitable viscosity range for molding the reactive composition can be about 2,000-30,000 cP, such as about 8,000-15,000 cP.

[0082] For illustration, the prepolymer and curative can be mixed in a motorized mixer inside a mixing head by metering amounts of the curative and prepolymer through the feed lines. Top preheated mold halves can be filled and placed in fixture units using centering pins moving into apertures in each mold half. At a later time, the cavity of a bottom mold half, or the cavities of a series of bottom mold halves, can be filled with similar mixture amounts as used in the top mold halves. After the reacting materials have resided in top mold

halves for about 40-100 seconds, such as about 50-90 seconds, about 60-80 seconds, or about 70-80 seconds, golf ball subassemblies such as cores can be lowered at a controlled speed into the reacting mixture. Ball cups can hold the subassemblies by applying reduced pressure (or partial vacuum). Upon location of the subassemblies in the top mold halves after gelling for about 4-12 seconds, such as about 5-10 seconds, the vacuum can be released to release the subassembly. The top mold halves can then be removed from the centering fixture unit, inverted and mated with the bottom mold halves having a selected quantity of reacting composition gelling therein. Other non-limiting molding techniques include those disclosed in U.S. Pat. Nos. 5,006,297 and 5,334,673, and others known to those skilled in the art, which are incorporated herein by reference.

[0083] Injection molding and/or compression molding may be used. For example, half-shells of thermoplastic compositions may be made by injection molding or compression molding in conventional half-shell molds, then placed about the pre-formed subassembly within a compression molding machine, and compression molded at about 250-400° F. The molded balls can then be cooled in the mold and removed when the molded layer is hard enough to be handled without deforming. Prior to forming the layer, the subassembly may be surface treated to increase the adhesion between the subassembly and the molded layer. Examples of surface treatment techniques can be found in U.S. Pat. No. 6,315,915, which are incorporated by reference.

Dimples

[0084] The use of various dimple patterns and profiles provides a relatively effective way to modify the aerodynamic characteristics of a golf ball. As such, the manner in which the dimples are arranged on the surface of the ball can be by any available method. In one example, the golf ball has about 250 to 450 dimples on its cover, the patterns of which include those disclosed in the parent U.S. application Ser. No. 10/859,557.

Golf Ball Post-Processing

[0085] The golf balls of the present disclosure may be painted, coated, or surface treated for further advantages. The use of light stable reactive compositions may obviate the need for certain post-processing such as applying pigmented coating or clear topcoat, thus reducing cost and production time, reducing use of volatile organic compounds (VOCs), and improving labor efficiency. Toning the golf ball cover with titanium dioxide can enhance its whiteness. The cover can be subjected to such surface treatment as corona treatment, plasma treatment, UV treatment, flame treatment, electron beam treatment, and/or applying one or more layers of clear paint, which optionally may contain one or more fluorescent whitening agents. Trademarks and/or other indicia may be stamped, i.e., pad-printed, on the cover, and then covered with one or more clear coats for protection and glossy look. UV treatment can be used to cure UV-curable topcoat and/or ink layer (used as a paint layer or a discrete marking tool for logo and indicia), as disclosed in, for example, U.S. Pat. Nos. 6,500,495, 6,248,804, and 6,099,415. One or more portions of the golf ball may be subjected to dye sublimation, as disclosed in U.S. Patent Publication No. 2003/0106442, and/or laser marking or ablation, as disclosed in U.S. Pat. Nos.

5,248,878 and 6,462,303. The disclosures of these patents and publications are incorporated by reference herein.

Golf Ball Properties

[0086] Physical properties of each golf ball portion, such as hardness, modulus, compression, and thickness/diameter, can affect play characteristics such as spin, initial velocity, and feel. It should be understood that the ranges herein are meant to be intermixed with one another, i.e., the low end of one range may be combined with the high end of another range.

Component Dimensions

[0087] Golf balls and portions thereof of the present disclosure can have any dimensions, i.e., thickness and/or diameter. While USGA specifications limit the size of a competition golf ball to 1.68 inches or greater in diameter, golf balls of any sizes smaller or larger can be used for leisure play. As such, the golf ball diameter can be 1.68-1.8 inches, 1.68-1.76 inches, 1.68-1.74 inches, or 1.7-1.95 inches. Golf ball subassemblies comprising the core and one or more intermediate layers can have a diameter of 80-98% of that of the finished ball. The core may have a diameter of 0.09-1.65 inches, such as 1.2-1.63 inches, 1.3-1.6 inches, 1.4-1.6 inches, 1.5-1.6 inches, or 1.55-1.65 inches. Alternatively, the core diameter can be 1.54 inches or greater, such as 1.55 inches or greater, or 1.59 inches or greater, and 1.64 inches or less. The core diameter can be 90-98% of the ball diameter, such as 94-96%. When the core comprises an inner center and at least one outer core layer, the inner center can have a diameter of 0.9 inches or greater, such as 0.09-1.2 inches or 0.095-1.1 inches, and the outer core layer can have a thickness of 0.13 inches or greater, such as 0.1-0.8 inches, or 0.2 or less, such as 0.12-0.01 inches or 0.1-0.03 inches. Two, three, four, or more of outer core layers of different thickness such as the ranges above may be used in combination.

[0088] Thickness of the intermediate layer may vary widely, because it can be any one of a number of different layers, e.g., outer core layer, inner cover layer, wound layer, and/or moisture/vapor barrier layer. The thickness of the intermediate layer can be 0.3 inches or less, such as 0.1 inches, 0.09 inches, 0.06 inches, 0.05 inches, or less, and can be 0.002 inches or greater, such as 0.01 inches or greater. The intermediate layer thickness can be 0.01-0.045 inches, 0.02-0.04 inches, 0.025-0.035 inches, 0.03-0.035 inches. Two, three, four, or more of intermediate layers of different thickness such as the ranges above may be used in combination. The core and intermediate layer(s) together form an inner ball, which can have a diameter of 1.48 inches or greater, such as 1.5 inches, 1.52 inches, or greater, or 1.7 inches or less, such as 1.66 inches or less.

[0089] The cover thickness can be 0.35 inches or less, such as 0.12 inches, 0.1 inches, 0.07 inches, or 0.05 inches or less, and 0.01 inches or greater, such as 0.02 inches or greater. The cover thickness can be 0.02-0.05 inches, 0.02-0.045 inches, or 0.025-0.04 inches, such as about 0.03 inches. Thickness ratio of the intermediate layer (e.g., as an inner cover layer) to the cover (e.g., as an outer cover layer) can be 10 or less, such as 3 or less, or 1 or less.

Hardness

[0090] Golf balls can comprise layers of different hardness, e.g., hardness gradients, to achieve desired performance char-

acteristics. The hardness of any two adjacent or adjoined layers can be the same or different. One of ordinary skill in the art understands that there is a difference between "material hardness" and "hardness, as measured directly on a golf ball." Material hardness is defined by the procedure set forth in ASTM-D2240 and generally involves measuring the hardness of a flat "slab" or "button" formed of the material in question. Hardness, when measured directly on a golf ball (or other spherical surface) is influenced by a number of factors including, but not limited to, ball construction (i.e., core type, number of core and/or cover layers, etc.), ball (or sphere) diameter, and the material composition of adjacent layers, and can therefore be different from the material hardness. The two hardness measurements are not linearly related and, therefore, cannot easily be correlated.

[0091] The cores of the present disclosure may have varying hardness depending at least in part on the golf ball construction. The core hardness as measured on a formed sphere can be at least 15 Shore A, such as at least 30 Shore A, about 50 Shore A to about 90 Shore D, about 80 Shore D or less, about 30-65 Shore D, or about 35-60 Shore D. The intermediate layer(s) of the present disclosure may also vary in hardness, depending at least in part on the ball construction. The hardness of the intermediate layer can be about 30 Shore D or greater, such as about 50 Shore D or greater, about 55 Shore D or greater, or about 65 Shore D or greater, and can be about 90 Shore D or less, such as about 80 Shore D or less or about 70 Shore D or less, or about 55-65 Shore D. The intermediate layer can be harder than the core layer, having a ratio of hardness of about 2 or less, such as about 1.8 or less, or about 1.3 or less. The intermediate layer can be different (i.e., harder or softer) than the core layer with a hardness difference of at least 1 unit in Shore A, C, or D, such as at least 3 units, or at least 5 units, or at least 8 units, or at least 10 units, or less than 20 units, or less than 10 units, or less than 5 units.

[0092] The hardness of the cover layer may vary, depending at least in part on the construction and desired characteristics of the golf ball. On the Shore C scale, the cover layer may have a hardness of about 70 Shore C or greater, such as about 80 Shore C or greater, and about 95 Shore C or less, such as about 90 Shore C or less.

[0093] The difference or ratio of hardness between the cover layer and the inner ball can be manipulated to influence the aerodynamics and/or spin characteristics of a ball. When the intermediate layer (such as inner cover layer) is at least harder than the cover layer (such as outer cover layer), or intended to be the hardest portion in the ball, e.g., about 50-75 Shore D, the cover layer may have a material hardness of about 20 Shore D or greater, such as about 25 Shore D or greater, or about 30 Shore D or greater, or the cover hardness as measured on the ball can be about 30 Shore D or greater, such as about 30-70 Shore D, about 40-65 Shore D, about 40-55 Shore D, less than about 45 Shore D, less than about 40 Shore D, about 25-40 Shore D, or about 30-40 Shore D. The material hardness ratio of softer layer to harder layer can be about 0.8 or less, such as about 0.75, about 0.7, about 0.5, about 0.45, or less. When the intermediate layer and the cover layer have substantially the same hardness, the material hardness ratio can be about 0.9 or greater, and up to 1.0, and the cover layer may have a hardness of about 55-65 Shore D. Alternatively, the cover layer can be harder than the intermediate layer, with the hardness ratio of the cover layer to the intermediate layer being about 1.33 or less, such as about 1.14 or less.

[0094] The core may be softer than the cover. For example, the cover hardness may be about 50-80 Shore D, and the core hardness may be about 30-50 Shore D, with the hardness ratio being about 1.75 or less, such as about 1.55 or less or about 1.25 or less.

Compression

[0095] As used herein, the terms “Atti compression” or “compression” refers to the deflection of an object or material relative to the deflection of a calibrated spring, as measured with an Atti Compression Gauge available from Atti Engineering Corp. of Union City, N.J. Compression values of the golf ball or portion thereof can be at least in part dependent on the diameter. Atti compression of the core or portion thereof can be 80 or less, such as 75 or less, 40-80, 50-70, 50 or less, 25 or less, 20 or less, 10 or less, or 0, or below the measurable limit of the Atti Compression Gauge. The core or portion thereof may have a Soft Center Deflection Index (SCDI) compression of 160 or less, such as 40-160 or 60-120. The golf ball can have an Atti compression of 40 or greater, such as 55 or greater, 50-120, 60-120, 50-120, 60-100, 75-95, or 80-95.

Initial Velocity and COR

[0096] USGA limits the initial velocity of a golf ball up to 250 ± 5 ft/s. The initial velocity of the golf ball of the present disclosure can be 245-255 ft/s, or greater, such as 250 ft/s or greater, 253-254 ft/s, or about 255 ft/s. Coefficient of restitution (COR) of a ball or a portion thereof is measured by taking the ratio of the outbound or rebound velocity to the inbound or incoming velocity (such as, but not limited to, 125 ft/s). COR can be maximized so that the initial velocity is contained with a certain limit. COR of the golf ball can be 0.7 or greater at an inbound velocity of 125 ft/s, such as 0.75 or greater, 0.78 or greater, 0.8 or greater, and up to about 0.85, such as 0.8-0.815. The core and/or the inner ball can have a COR of 0.78 or more, such as 0.79 or greater.

Spin Rate

[0097] Spin rate of a golf ball can at least in part be dependent on construction, and can vary off different golf clubs (e.g., driver, woods, irons, wedges, etc.). In a multi-layer (e.g., 2-piece, 3-piece, 4-piece, wound) ball, the driver spin rate can be 2,700 rpm or greater, such as 2,700-3,300 rpm, 2,800-3,500 rpm, 2,900-3,400 rpm, or less than 2,700 rpm. Non-limiting measurements of spin rate are disclosed in U.S. Pat. Nos. 6,500,073, 6,488,591, 6,286,364, and 6,241,622, which are incorporated by reference herein.

Flexural Modulus

[0098] As used herein, the term “flexural modulus” or “modulus” refers to the ratio of stress to strain within the elastic limit (measured in flexural mode) of a material, indicates the bending stiffness of the material, and is similar to tensile modulus. Flexural modulus, typically reported in Pascal (“Pa”) or pounds per square inch (“psi”), is measured in accordance to ASTM D6272-02.

[0099] The intermediate layer (e.g., outer core layer, inner cover layer) can have any flexural modulus of 500-500,000 psi, such as 1,000-250,000 psi or 2,000-200,000 psi. The flexural modulus of the cover layer (e.g., outer cover layer, inner cover layer, intermediate cover layer) can be 2,000 psi or greater, such as 5,000 psi or greater, 10,000-150,000 psi, 15,000-120,000 psi, 18,000-110,000 psi, 100,000 psi or less, 80,000 or less, 70,000 psi or less, 10,000-70,000 psi, 12,000-60,000 psi, or 14,000-50,000 psi.

15,000-120,000 psi, 18,000-110,000 psi, 100,000 psi or less, 80,000 or less, 70,000 psi or less, 10,000-70,000 psi, 12,000-60,000 psi, or 14,000-50,000 psi.

[0100] The cover layer (e.g., inner cover, intermediate cover, outer cover layers) can have any flexural modulus, such as the numerical ranges illustrated for intermediate layer above. When the cover layer has a hardness of 50-60 Shore D, the flexural modulus can be 55,000-65,000 psi. In multi-layer covers, the cover layers can have substantially the same hardness but different flexural moduli. The difference in flexural modulus between any two cover layers can be 10,000 psi or less, 5,000 psi or less, or 500 psi or greater, such as 1,000-2,500 psi. The ratio in flexural modulus of the intermediate layer to the cover layer can be 0.003-50, such as 0.006-4.5 or 0.11-4.5.

Specific Gravity

[0101] The specific gravity of a cover or intermediate layer can be at least 0.7, such as 0.8 or greater, 0.9 or greater, 1 or greater, 1.05 or greater, or 1.1 or greater. The core may have a specific gravity of 1 or greater, such as 1.05 or greater. In one example, the intermediate layer has a specific gravity of 0.9 or greater and the cover has a specific gravity of 0.95 or greater. In another example, the core specific gravity is 1.1 or greater and the cover specific gravity is about 0.95 or greater.

Adhesion Strength

[0102] The adhesion, or peel, strength of the compositions as presently disclosed can be 5 lb/in or greater, such as 10 lb/in or greater, 20 lb/in or greater, 24 lb/in or greater, or 26 lb/in or greater, or 30 lb/in or less, such as 25 lb/in, 20 lb/in, or less. Adhesion strength of a golf ball layer can be assessed using cross-hatch test (i.e., cutting the material into small pieces in mutually perpendicular directions, applying a piece of adhesive cellophane tape over the material, rapidly pulling off the tape, and counting the number of pieces removed) and repeated ball impact test (i.e., subjecting the finished golf ball to repeated impact and visually examining the coating film for peeling), as disclosed in U.S. Pat. No. 5,316,730, which is incorporated by reference herein.

Water Resistance

[0103] Water resistance of a golf ball portion can be reflected by absorption (i.e., weight gain following a period of exposure at a specific temperature and humidity differential) and transmission (i.e., water vapor transmission rate (WVTR) according to ASTM E96-00, which refers to the mass of water vapor that diffuses into a material of a given thickness per unit area per unit time at a specific temperature and humidity differential). The golf ball or a portion thereof can have a weight gain of 0.15 g or less, such as 0.13 g, 0.09 g, 0.06 g, 0.03 g, or less, and a diameter gain of 0.001 inches or less, over seven weeks at 100% relative humidity and 72° F. The golf ball portion such as the outer or inner cover layer can have a WVTR of 2 g/(m²×day) or less, such as 0.45-0.95 g/(m²×day), 0.01-0.9 g/(m²×day), or less, at 38° C. and 90% relative humidity.

Shear/Cut Resistance

[0104] The shear/cut resistance of a golf ball portion (e.g., inner or outer cover layer) may be determined using a shear

test having a scale from 1 to 6 in damage and appearance. The cover layer can have a number of 3, 2, 1, or less on the shear test scale.

Light Stability

[0105] Light stability (such as to UV irradiance power of 1.00 Wm²/nm) of the cover layer (e.g., a visible layer such as an outer cover layer or an inner/intermediate cover layer having transparent or translucent outer cover layers) may be quantified using difference in yellowness index (ΔYI , according to ASTM D1925) before and after a predetermined period (such as 120 hrs) of exposure. The ΔYI of the cover layer can be 10 or less, such as 6, 4, 2, 1, or less. Difference in yellow-to-blue chroma dimension before and after the exposure (Δb^*) can also quantify light stability. The Δb^* of the cover layer can be 4 or less, such as 3, 2, 1, or less.

[0106] The compositions for golf ball portions as disclosed herein may be used in sporting equipment in general. Specifically, the compositions may be applied in various game balls, golf club shafts, golf club head inserts, golf shoe components, and the like.

[0107] As used herein, the terms "araliphatic", "aryl aliphatic," or "aromatic aliphatic" all refer to compounds that contain one or more aromatic moieties and one or more aliphatic moieties, where the reactable functional groups such as, without limitation, isocyanate groups, amine groups, and hydroxyl groups are directly linked to the aliphatic moieties and not directly bonded to the aromatic moieties. Illustrative examples of araliphatic compounds are o-, m-, and p-tetramethylxylene diisocyanate (TMXDI).

[0108] The subscript letters such as m, n, x, y, and z used herein within the generic structures are understood by one of ordinary skill in the art as the degree of polymerization (i.e., the number of consecutively repeating units). In the case of molecularly uniformed products, these numbers are commonly integers, if not zero. In the case of molecularly non-uniformed products, these numbers are averaged numbers not limited to integers, if not zero, and are understood to be the average degree of polymerization.

[0109] Any numeric references to amounts, unless otherwise specified, are "by weight." The term "equivalent weight" is a calculated value based on the relative amounts of the various ingredients used in making the specified material and is based on the solids of the specified material. The relative amounts are those that result in the theoretical weight in grams of the material, like a polymer, produced from the ingredients and give a theoretical number of the particular functional group that is present in the resulting polymer.

[0110] As used herein, the term "polymer" refers to oligomers, adducts, homopolymers, random copolymers, pseudo-copolymers, statistical copolymers, alternating copolymers, periodic copolymer, bipolymers, terpolymers, quaterpolymers, other forms of copolymers, substituted derivatives thereof, and combinations of two or more thereof. These polymers can be linear, branched, block, graft, monodisperse, polydisperse, regular, irregular, tactic, isotactic, syndiotactic, stereoregular, atactic, stereoblock, single-strand, double-strand, star, comb, dendritic, and/or ionomeric.

[0111] As used herein, the term "telechelic" refers to polymers having at least two terminal reactive end-groups and capable of entering into further polymerization through these reactive end-groups. Reactive end-groups disclosed herein

include, without limitation, amine groups, hydroxyl groups, isocyanate groups, carboxylic acid groups, thiol groups, and combinations thereof.

[0112] As used herein, the term "polyahl" or "reactive polyahl" refers to any one compound or a mixture of compounds containing a plurality of active hydrogen moieties per molecule. Illustrative of such active hydrogen moieties are —OH (hydroxy group), —SH (thio group), —COOH (carboxylic acid group), and —NHR (amine group), with R being hydrogen, alkyl, aryl, or epoxy; all of which may be primary or secondary. These active hydrogen moieties are reactive to free isocyanate groups, forming urethane, urea, thiourea or corresponding linkage depending on the particular active hydrogen moiety being reacted. The polyahls may be monomers, homo-oligomers, co-oligomers, homopolymers, or copolymers, and include the compounds described in U.S. Pat. Nos. 4,394,491 and 4,822,827. Oligomeric and polymeric polyahls having at least one NCO-reactive group on each terminal of a backbone are typically employed as the soft segment in reaction products such as polyureas and polyurethanes. Depending on the terminal groups, the oligomeric and polymeric polyahls may be identified as polyols (with —OH terminals only), polyamines (with —NHR terminals only), or aminoalcohol oligomers or polymers (with both —OH and —NHR terminals). Such polyahls with a relatively low molecular weight (less than about 5,000), and a wide variety of monomeric polyahls, are commonly used as curing agents. The polyahls are generally liquids or solids meltable at relatively low temperatures.

[0113] As referred to herein, lower alkyls and lower alkoxies include C₁₋₅, preferably C₁₋₃, alkyls and alkoxies, such as methyl, ethyl, n-propyl, isopropyl, n-butyl, sec-butyl, t-butyl, amyl, isoamyl, methoxy, ethoxy, isopropoxy, isobutoxy, t-butoxy.

[0114] As referred to herein, halogens include fluorine, chlorine, bromine, and iodine.

[0115] As referred to herein, linear or branched alkyls include methyl, ethyl, n-propyl, isopropyl, n-butyl, sec-butyl, t-butyl, amyl, isoamyl, n-hexyl, 2-ethyl-n-hexyl, n-heptyl, n-octyl, isoctyl, n-nonyl, isononyl, n-dodecyl.

[0116] As referred to herein, substituted alkyls include cyanoalkyl, haloalkyl, hydroxyalkyl, alkoxyalkyl, preferably C₂₋₆, e.g., β-cyanoethyl, β-chloroethyl, β-hydroxyethyl, β-methoxyethyl, β-ethoxyethyl. Cycloalkyls include cyclopentyl, cycloheptyl, cyclohexyl, and may comprise one or more C₁₋₄ alkyls.

[0117] As referred to herein, aralkyls and alkaryls include methylbenzyl, phenethyl, phenisopropyl, benzyl, and may be ring-substituted, such as with halogen, methyl, and/or methoxy, like p-methylbenzyl, o- or p-chlorobenzyl, o- or p-tolyl, xylyl, o-, m- or p-chlorophenyl, and o- or p-methoxyphenyl.

[0118] As referred to herein, heterocyclic radicals include pyrrolidinyl, piperidinyl, piperolinyl, morpholinyl, thiomorpholinyl, piperazinyl (e.g., N-methylpiperazinyl).

[0119] As used herein, the term "derivatives" refers to various compounds chemically derivable from the parent compounds, typically sharing one or more chemical properties and/or reactivities with the parent compounds. When applicable, the derivatives of the compounds disclosed herein include, without limitation, substitution derivatives having one or more substituents, anhydrides, dimers, oligomers, esters such as alkyl (e.g., methyl, ethyl, linear or branched C₁₋₁₂ alkyls), cycloalkyl, and aryl esters, amides, halides, oxides, sulfides, and salts having metal cations (e.g., Na, K,

Zn, Ca, Co, Mg, Ni), organometallic cations, and non-metal cations (e.g., quaternary ammonium, quaternary pyridinium, quaternary quinolinium, (organo)phosphonium, (organo)sulfonium, (organo)oxonium, (organo)iodonium, (organo)azonium).

[0120] Other than in the operating examples, or unless otherwise expressly specified, all of the numerical ranges, amounts, values and percentages such as those for amounts of materials, times and temperatures of reaction, ratios of amounts, values for molecular weight (whether number average molecular weight ("M_n") or weight average molecular weight ("M_w"), and others in the following portion of the specification may be read as if prefaced by the word "about" even though the term "about" may not expressly appear with the value, amount or range. Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present disclosure. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

[0121] Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the disclosure are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contain certain errors necessarily resulting from the standard deviation found in their respective testing measurements. Furthermore, when numerical ranges of varying scope are set forth herein, it is contemplated that any combination of these values inclusive of the recited values may be used.

[0122] For molecular weights, whether M_n or M_w, these quantities are determined by gel permeation chromatography using polystyrene as standards as is well known to those skilled in the art and such as is discussed in U.S. Pat. No. 4,739,019 at column 4, lines 2-45, which is incorporated herein by reference in its entirety.

[0123] As used herein, the terms "polydispersity" and "dispersity" refer to the ratio of M_w to M_n, an indicator of the degree of molecular weight distribution of a polymer and the extent to which the polymer chains share the same degree of polymerization. Polydispersity has a theoretical minimum of 1.0.

[0124] As used herein, the terms "formed from" and "formed of" denote open, e.g., "comprising," claim language. As such, it is intended that a composition "formed from" or "formed of" a list of recited components be a composition comprising at least these recited components, and can further comprise other non-recited components during formulation of the composition.

[0125] As used herein, the term "cure" as used in connection with a composition, e.g., "a curable material", "a cured composition," shall mean that any crosslinkable components of the composition are at least partially crosslinked. In certain examples of the present disclosure, the degree of crosslinking can range from 5% to 100% of complete crosslinking. In other examples, the degree of crosslinking can range from 35% to 85% of full crosslinking. In other examples, the degree of crosslinking can range from 50% to 85% of full crosslinking. One skilled in the art will understand that the presence and degree of crosslinking can be determined by a

variety of methods, such as dynamic mechanical thermal analysis (DMTA) in accordance with ASTM E1640-99.

[0126] As used herein, the term "saturated" or "substantially saturated" means that the compound or material of interest is fully saturated (i.e., contains no double bonds, triple bonds, or aromatic ring structures), or that the extent of unsaturation is negligible, e.g. as shown by a bromine number in accordance with ASTM E234-98 of less than 10, or less than 5.

[0127] As used herein, the term "percent NCO" or "% NCO" refers to the percent by weight of free, reactive, and unreacted or blocked (e.g., with phenols or ketoxime) isocyanate functional groups in an isocyanate-functional molecule or material. The total formula weight of all the NCO groups in the molecule or material, divided by its total molecular weight, and multiplied by 100, equals the percent NCO.

[0128] As used herein, the term "equivalent" is defined as the number of moles of a functional group in a given quantity of material, and calculated from material weight divided by equivalent weight, the later of which refers to molecular weight per functional group. For isocyanates the equivalent weight is (4210 grams)/% NCO; and for polyols, (56100 grams)/OH#.

[0129] As used herein, the term "flexural modulus" or "modulus" refers to the ratio of stress to strain within the elastic limit (measured in flexural mode) of a material, indicates the bending stiffness of the material, and is similar to tensile modulus. Flexural modulus, typically reported in Pa or psi, is derived in accordance to ASTM D6272-02.

[0130] As used herein, the term "water vapor transmission rate" ("WVTR") refers to the mass of water vapor that diffuses into a material of a given thickness (e.g., 1 mm) per unit area (e.g., 1 m²) per unit time (e.g., 24 h) at a specific temperature (e.g., 38° C.) and humidity differential (e.g., 90% relative humidity). Standard test methods for WVTR include ASTM E96-00, method E, ASTM D1653-03, and ASTM F1249-01.

[0131] As used herein, the term "material hardness" refers to indentation hardness of non-metallic materials in the form of a flat slab or button as measured with a durometer. The durometer has a spring-loaded indenter that applies an indentation load to the slab, thus sensing its hardness. The material hardness can indirectly reflect upon other material properties, such as tensile modulus, resilience, plasticity, compression resistance, and elasticity. Standard tests for material hardness include ASTM D2240-02b. Unless otherwise specified, material hardness reported herein is in Shore D. Material hardness is distinct from the hardness of a golf ball portion as measured directly on the golf ball (or other spherical surface). The difference in value is primarily due to the construction, size, thickness, and material composition of the golf ball components (i.e., center, core and/or layers) that underlie the portion of interest. One of ordinary skill in the art would understand that the material hardness and the hardness as measured on the ball are not correlated or convertible.

[0132] As used therein, the term "compression," also known as "Atti compression" or "PGA compression," refers to points derived from a Compression Tester (ATTI Engineering Company, Union City, N.J.), a scale well known in the art for determining relative compression of a spherical object. Atti compression is approximately related to Riehle compression: Atti compression ≈ (160 - Riehle compression). Com-

pression is a property of a material as measured on a golf ball construction (i.e., on-ball property), not a property of the material per se.

[0133] As used herein, the term “coefficient of restitution” or “CoR” for golf balls or subassemblies thereof is defined as the ratio of a ball’s rebound velocity to its initial incoming velocity when the ball is fired out of an air cannon into a vertical, stationary, steel plate which provides an impact surface weighing about 100 pounds or about 45 kilograms. The time periods, T_{in} and T_{out} of the ball flight between two separate ballistic light screens placed between the air cannon and the plate are measured to calculate $CoR = T_{out}/T_{in}$. The faster a golf ball rebounds, the higher the CoR it has, the more the total energy it retains when struck with a club, and the longer the ball flies. The reported CoR’s initial velocity is about 50 ft/s to about 200 ft/s, and is usually understood to be 125 ft/s, unless otherwise specified. A golf ball may have different CoR values at different initial velocities.

[0134] Another CoR measuring method uses a launching device, a circular titanium disk of 200 g and 4-inch in diameter to simulate a golf club, and two separate ballistic light screens placed there between. The impact face of the disk may also be flexible and has its own CoR. From the two time periods, disk mass (M_e), and ball mass (M_b), CoR can be calculated as follows:

$$CoR = \frac{(T_{out}/T_{in}) \times (M_e + M_b) + M_b}{M_e}$$

[0135] A “Mooney” viscosity is a unit used to measure the plasticity of raw or unvulcanized rubber. The plasticity in a Mooney unit is equal to the torque, measured on an arbitrary scale, on a disk in a vessel that contains rubber at a temperature of 100° C. and rotates at two revolutions per minute. The measurement of Mooney viscosity is defined according to ASTM D-1646.

[0136] As used herein and to conventional practice, the unit “phr” refers to “parts by weight of a respective material per 100 parts by weight of the base polymer or polymer blend.”

[0137] When numerical lower limits and numerical upper limits are set forth herein, it is contemplated that any combination of these values may be used.

[0138] All patents, publications, test procedures, and other references cited herein, including priority documents, are fully incorporated by reference to the extent such disclosure is not inconsistent with this invention and for all jurisdictions in which such incorporation is permitted.

[0139] While the illustrative embodiments of the invention have been described with particularity, it will be understood that various other modifications will be apparent to and can be readily made by those of ordinary skill in the art without departing from the spirit and scope of the invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the examples and descriptions set forth herein, but rather that the claims be construed as encompassing all of the features of patentable novelty which reside in the present invention, including all features which would be treated as equivalents thereof by those of ordinary skill in the art to which the invention pertains.

What is claimed is:

1. A golf ball, comprising:

a core; and

at least one layer disposed about the core, the layer comprising a polyurea composition formed from a cycloaliphatic polyisocyanate prepolymer, a cycloaliphatic amine curative, and a tin catalyst.

2. The golf ball of claim 1, wherein the polyurea composition has a gel time of greater than 60 seconds:

3. The golf ball of claim 1, wherein the polyurea composition has a gel time of 80 seconds or greater.

4. The golf ball of claim 1, wherein the polyurea composition has a gel time of 100 seconds or greater.

5. The golf ball of claim 1, wherein the catalyst is used in an amount of 0.01% to 1% by weight of the composition.

6. The golf ball of claim 1, wherein the catalyst is used in an amount of 0.05% to 0.75% by weight of the composition.

7. The golf ball of claim 1, wherein the catalyst is present in an amount of 0.1% to 0.5% by weight of the composition.

8. The golf ball of claim 1, wherein the catalyst is dibutyltin dilaurate.

9. The golf ball of claim 1, wherein the amine curative is 4,4'-bis(sec-butylamino)-dicyclohexylmethane.

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