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(54) **GOLF BALL**

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(57) **ABSTRACT**

A golf ball including a core and at least one layer formed over the core. The layer can be an outer core layer, an intermediate layer including inner cover layers, or a cover. Either the core or any layer over the core can comprise a fully or partially neutralized polyester ionomer. The core comprises: a diameter of at least 1.30 inches, a compression of 50 or less; and a coefficient of restitution of 0.80 or greater at 125 ft/sec.

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GOLF BALL

FIELD OF THE INVENTION

[0001] This invention generally relates to a polyester ionomer that may be partially or fully neutralized and to the use of such compositions in golf balls.

BACKGROUND OF THE INVENTION

[0002] Golf balls have been designed to provide particular playing characteristics. These characteristics generally include initial ball velocity, coefficient of restitution (COR), compression, weight distribution and spin of the golf ball, which can be optimized for various types of players.

[0003] Golf balls can generally be divided into two classes: solid and wound. Solid golf balls include single-layer, dual-layer (i.e., solid core and a cover), and multi-layer (i.e., solid core of one or more layers and/or a cover of one or more layers) golf balls. Wound golf balls, which are rather rare today, typically include a solid, hollow, or fluid-filled center, surrounded by tensioned elastomeric thread, and a cover.

[0004] Golf ball core and cover layers are typically constructed with polymer compositions including, for example, polybutadiene rubber, polyurethanes, polyamides, ionomers, and blends thereof. Ionomers, particularly ethylene-based ionomers, are a preferred group of polymers for golf ball layers because of their toughness, durability, and wide range of hardness values.

[0005] Ionomers are stiffened by increasing the amount of neutralization to 70% and higher. However, in the absence of flow additives, neutralization levels above about 60% will decrease the melt flow of the ionomer to an extent such that process ability decreases or disappears altogether. Blending ionomers with fatty acids is a known method for improving the process ability of highly neutralized polymers. For example, U.S. Pat. No. 6,653,382 discloses melt-process capable, highly-neutralized ethylene acid copolymers and a method for making them which incorporates an aliphatic, mono-functional organic acid in the acid copolymer and then neutralizing it with greater than 90% of all of the acid groups present.

[0006] Generally, the hardness of a golf ball or a golf ball core is one among other factors used in designing golf balls. Typically, when a ball is hard, e.g., possessing high compression values and low deformation when struck by a club, it typically has high COR and high initial velocity after impact with a golf club. However, a hard ball has a "hard" feel and is difficult to control around the greens. A softer ball, e.g., lower compression value and high deformation, has a "soft" feel and is easier to control with short iron clubs for greenside play. To obtain a wide range of material hardness, block copolymers are often produced which contain soft segments and hard segments, amounts of which can be varied to give desired properties. However, stiff materials that contain higher amounts of hard segments suffer from brittleness and poor resilience. In general, softer polyester materials tend to have better resilience and durability but can become too soft for golf ball applications.

[0007] It has been determined that, upon the addition of a partially or fully neutralized polyester ionomer, golf balls may be constructed that exhibit increased COR without sacrificing durability. The present invention is, therefore,

directed to a golf ball cover, core, or any intermediate layer that includes a polyester ionomer.

SUMMARY OF THE INVENTION

[0008] In one embodiment, the present invention is directed to a golf ball having a core, and at least one layer over the core, wherein the core or the at least one layer comprises a material formed from a composition comprising a partially or fully neutralized polyester ionomer. The golf ball may include a single cover over the core or it may include: a core, core layer and cover; core, core layer, at least one intermediate layer, and a cover; or a core, at least one intermediate layer and a cover.

[0009] The present invention provides for including into the polyester at least one monomer containing an ionic or acidic moiety such as sulfonate or carboxylate. Monomers used to make the polyester ionomer may include dimethyl phthalate, terephthalic acid, PTMEG, PPG, PEO, butane diol, isophthaloyl chloride, polybutadiene diol, dimethyl sebacate, 3-sodium sulfophthalic acid, 5-sulfoisophthalate, or phthalic anhydride. The ionic moiety comprises counter-ions selected from the group consisting of Li, Na, K, Mg, Ca, Sr, Zn, Al, ammonium and alkylammonium metal cations. To allow for desirable processing qualities, a viscosity reducer or flow modifier may be added. Flow modifiers may be fatty acid or salt thereof, plasticizer or solvent.

[0010] An embodiment of the invention provides for the cover to have a Shore D hardness of about 60 or less. The combination of the core and the at least one layer results in the golf ball having a coefficient of restitution of 0.810 to 0.825 when measured at an incoming velocity of 125 ft/s. The core having a Shore C hardness greater than 70, and a compression greater than 80.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] The golf balls of the present invention can comprise a polyester ionomer in the cover, core, core layer and/or any intermediate layers between the cover and core. The polyester ionomer may be partially or fully neutralized and may contain a flow modifier.

[0012] The present invention offers alternatives to conventional thermoplastic polyester elastomers including polyether-esters marketed under trade names such as DuPont's Hytrel® or Ticona's Riteflex®.

[0013] To obtain a wide range of material hardness, block copolymers are often produced containing soft and hard segments, the amounts of which are varied to give desired physical properties. However, stiff materials that contain higher amounts of hard segments suffer from brittleness and poor resilience. In general the softer materials tend to have better resilience and durability, but they can become too soft for practical applications. The present invention has found that the incorporation of ionic moieties into polyesters yields materials with a wider variety of physical properties and improved performance. The improved performance includes increased Coefficient of Restitution (COR) and durability.

[0014] Ionic groups can be incorporated into polyesters by a variety of different methods. Typically this is done by including a monomer that contains the ionic moiety (e.g. sulfonate or carboxylate) and introducing it during a condensation polymerization phase of the process. Another method is the post-polymerization modification (sulfonation or carboxylation) of the polyester. Condensation polymerization to

form polyesters can be carried out by a number of different esterification methods including transesterification, direct alcohol/acid condensation, or through the use of acid chlorides or anhydrides and alcohols. The starting monomers may include multifunctional acids, multifunctional alcohols, multifunctional esters, multifunctional acyl halides, and hydroxyl acids which can be cyclic, polycyclic, aromatic, or aliphatic. Sulfonated or carboxylated versions of these monomers would be used to incorporate the ionic groups. The ionic monomers may be part of the hard segment or soft segment.

[0015] Specific monomers that may be used include dimethyl phthalate, terephthalic acid, polytetramethyleneetherglycol (PTMEG), butane diol, isophthaloyl chloride, polybutadiene diol, dimethyl sebacate, 3-sodium sulfophthalic acid, 5-sulfoisophthalate, or phthalic anhydride. Cyclic esters could also be used as a potential monomer.

[0016] The ionic groups may be neutralized with any suitable counter-ion such as Li, Na, K, Mg, Ca, Sr, Zn, Al, ammonium, or alkylammonium. Ionic monomers may be neutralized or un-neutralized prior to the polymerization. It is to be appreciated that incorporation of higher amounts of the ionic monomers may also require a viscosity reducer or flow modifier to allow for desirable polymerization and processing. The resulting materials can be partially or fully neutralized. Because of the versatility of the synthesis these materials can be used in any layer of a golf ball from stiff cover or casings to soft centers or cores.

[0017] The golf balls of the present invention may comprise any of a variety of constructions, such as a two-piece, three-piece, multi-layer, or wound ball having a variety of cores, intermediate layers, covers, and coatings. The covers and cores of the present invention include structures including one or more layers. Cores may include a single, unitary layer, comprising the entire core from the center of the core to its outer periphery, or may contain a center surrounded by at least one outer core layer. The center, the innermost portion of the core, is preferably solid, but may be hollow or liquid-gel, or gas-filled. The outer core layer may also be a wound layer formed of a tensioned elastomeric material. Cover layers of the present invention may also contain one or more layers, such as a double cover comprising an inner and outer cover layer. Optionally, an intermediate layer disposed between the core and cover may be incorporated. The intermediate layer, if present, may comprise one or more layers, and are sometimes referred to in the art, and, thus, herein as well, as inner cover layers, outer core layers, or mantle layers.

[0018] The materials for solid cores include compositions having a base rubber, a crosslinking agent, filler, a halogenated organosulfur compound, and a co-crosslinking or initiator agent. The base rubber typically includes natural or synthetic rubbers. A preferred base rubber is 1,4-polybutadiene having a cis-structure of at least 40%, more preferably at least about 90%, and most preferably at least about 95%. Most preferably, the base rubber comprises high-Mooney-viscosity rubber. Preferably, the base rubber has a Mooney viscosity greater than about 35, more preferably greater than about 50. Preferably, the polybutadiene rubber has a molecular weight greater than about 400,000 and a polydispersity of no greater than about 2.

[0019] The crosslinking agent includes a metal salt, such as zinc or magnesium salt of an unsaturated acid, such as acrylic or methacrylic acid, having 3 to 8 carbon atoms. Examples include, but are not limited to, one or more metal salt diacrylates, dimethacrylates, and monomethacrylates, wherein the

metal is magnesium, calcium, zinc, aluminum, sodium, lithium, or nickel. Preferred acrylates include zinc acrylate, zinc diacrylate, zinc methacrylate, zinc dimethacrylate, and mixtures thereof. The crosslinking agent is typically present in an amount greater than about 10 parts per hundred ("pph") parts of the base polymer, preferably from about 20 to 40 pph of the base polymer, more preferably from about 25 to 35 pph of the base polymer. In another embodiment of the present invention, the crosslinking agent is present in an amount of less than about 25 pph of the base polymer or, in an alternative embodiment, in an amount greater than about 40 pph of the base polymer. It is preferred that in these two low- and high-level crosslinking agent embodiments, that the organosulfur compound is present in an amount of less than about 2 pph, more preferably less than about 1.5 pph, and most preferably, less than about 0.75 pph.

[0020] In one embodiment, the cross-linker is present in the core composition an amount of less than about 25 pph and the co-curing agent is present in an amount sufficient to increase both compression and COR. In another embodiment, the cross-linker is present in the core composition an amount of between about 25 pph and about 40 pph and the co-curing agent is present in an amount sufficient to increase compression but not COR. Additionally, the cross-linker may be present in the core composition an amount greater than about 40 pph and the co-curing agent is present in an amount sufficient to increase compression and decrease COR.

[0021] The initiator agent can be any known polymerization initiator which decomposes during the cure cycle. Suitable initiators include organic peroxide compounds, such as dicumyl peroxide; 1,1-di(t-butylperoxy) 3,3,5-trimethyl cyclohexane; α,α -bis (t-butylperoxy) diisopropylbenzene; 2,5-dimethyl-2,5 di(t-butylperoxy) hexane; di-t-butyl peroxide; and mixtures thereof. Other examples include, but are not limited to, VAROX® 231XL and VAROX® DCP-R, commercially available from R. T. Vanderbilt; PERKODOX® BC and PERKODOX® 14, commercially available from Akzo Nobel of Chicago, Ill.; and ELASTOCHEM® DCP-70, commercially available from Rhein Chemie of Trenton, N.J.

[0022] These classes of peroxides should allow close control of the decomposition temperature. Better control of decomposition temperature allows for increased crosslinking efficiency resulting in increased COR for cores made from these peroxides. Further, a greater variety of core formulations and processes are available because cure cycle times and temperatures can be controlled by changing the activation temperature of the peroxide(s) rather than the mold temperature. Additionally, the peroxides can be selected to have higher activation temperatures for improved safety from increased scorch times. The volatility of these peroxides is also reduced, compared to conventional peroxides, which will allow decreased peroxide loss during mixing resulting in more efficient mixing, more homogeneous compositions, and better efficiency.

[0023] Fillers typically include materials such as tungsten, zinc oxide, barium sulfate, silica, calcium carbonate, zinc carbonate, metals, metal oxides and salts, regrind (recycled core material typically ground to about 30 mesh particle), high-Mooney-viscosity rubber regrind, trans-regrind core material (recycled core material containing high trans-isomer of polybutadiene, prepared as described below), and the like. When trans-regrind is present, the amount of trans-isomer is preferably between about 10% and about 60%. In a preferred embodiment of the invention, the core comprises polybutadi-

ene having a cis- isomer content of greater than about 95% and trans-regrind core material (already vulcanized) as a filler. Any particle size trans-regrind core material is sufficient, but is preferably less than about 125 μm .

[0024] Fillers added to one or more portions of the golf ball typically include processing aids or compounds to affect rheological and mixing properties, density-modifying fillers, tear strength, or reinforcement fillers, and the like. The fillers are generally inorganic, and suitable fillers include numerous metals or metal oxides, such as zinc oxide and tin oxide, as well as barium sulfate, zinc sulfate, calcium carbonate, barium carbonate, clay, tungsten, tungsten carbide, an array of silicas, and mixtures thereof. Fillers may also include various foaming agents or blowing agents which may be readily selected by one of ordinary skill in the art. Fillers may include polymeric, ceramic, metal, and glass microspheres may be solid or hollow, and filled or unfilled. Fillers are typically also added to one or more portions of the golf ball to modify the density thereof to conform to uniform golf ball standards. Fillers may also be used to modify the weight of the center or at least one additional layer for specialty balls, e.g., a lower weight ball is preferred for a player having a low swing speed.

[0025] The invention also relates to a "modified" soft, resilient thermoplastic ionomer that comprises a melt blend of (a) the polyester 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%, preferably greater than 90% of all the acid of (a) and of (b) is neutralized. Preferably, 100% of all the acid of (a) and (b) is neutralized by a cation source. Preferably, an amount of cation source in excess of the amount required to neutralize 100% of the acid in (a) and (b) is used to neutralize the acid in (a) and (b). Blends with fatty acids or fatty acid salts are preferred.

[0026] The organic acids or salts thereof are added in an amount sufficient to enhance the resilience and processability of the copolymer.

[0027] Preferably, the organic acids or salts are added in an amount of at least about 5% (weight basis) of the total amount of copolymer. More preferably, the organic acids or salts thereof are added in an amount of at least about 15%, even more preferably at least about 20%. Preferably, the organic acid(s) are added in an amount up to about 50% (weight basis) based on the total amount of copolymer. More preferably, the organic acids or salts thereof are added in an amount of up to about 40%, more preferably, up to about 35%. The non-volatile, non-migratory organic acids preferably are one or more aliphatic, mono-functional organic acids or salts thereof as described below, particularly one or more aliphatic, mono-functional, saturated or unsaturated organic acids having less than 36 carbon atoms or salts of the organic acids, preferably stearic acid or oleic acid. Fatty acids or fatty acid salts are most preferred.

[0028] The organic acids employed are aliphatic, mono-functional (saturated, unsaturated, or multi-unsaturated) organic acids, particularly those having fewer than 36 carbon atoms. Also salts of these organic acids may be employed. Fatty acids or fatty acid salts are preferred. The salts may be any of a wide variety, particularly including the barium, lithium, sodium, zinc, bismuth, potassium, strontium, magnesium or calcium salts of the organic acids. Particular organic acids useful in the present invention include caproic

acid, caprylic acid, capric acid, lauric acid, stearic acid, behenic acid, erucic acid, oleic acid, and linoleic acid.

[0029] The optional filler component is chosen to impart additional density to blends of the previously described components, the selection being dependent upon the different parts (e.g., cover, mantle, core, center, intermediate layers in a multilayered core or ball) and the type of golf ball desired (e.g., one-piece, two-piece, three-piece or multiple-piece ball), as will be more fully detailed below.

[0030] Generally, the filler will be inorganic having a density greater than about 4 g/cm^3 , preferably greater than 5 g/cm^3 , and will be present in amounts between 0 to about 60 wt. % based on the total weight of the composition. Examples of useful fillers include zinc oxide, barium sulfate, lead silicate and tungsten carbide, as well as the other well-known fillers used in golf balls. It is preferred that the filler materials be non-reactive or almost non-reactive and not stiffen or raise the compression nor reduce the coefficient of restitution significantly.

[0031] The core composition of this invention comprises a polyester ionomer which, when formed into a sphere that is 1.50 to 1.54 inches in diameter, has a coefficient of restitution (COR) of at least 0.600 when measured by firing the sphere at an initial velocity of 125 feet/second against a steel plate positioned 3 feet from the point where initial velocity and rebound velocity are determined and by dividing the rebound velocity from the plate by the initial velocity and an Atti compression of no more than 100.

[0032] The core composition of this invention preferably comprises (a) aliphatic, mono-functional organic acid(s) having fewer than 36 carbon atoms; and (b) polyester ionomers thereof, wherein greater than 90%, preferably near 100%, and more preferably 100% of all the acid of (a) and (b) are neutralized.

[0033] The thermoplastic composition of this invention preferably comprises melt-processible, highly-neutralized (greater than 90%, preferably near 100%, and more preferably 100%) polymer of (1) polyester ionomers, and (2) non-volatile, non-migratory agents such as organic acids (or salts). Agents other than organic acids (or salts) may be used.

[0034] With the addition of sufficient organic acid, greater than 90%, nearly 100%, and preferably 100% of the copolymer acid moieties in the polyester copolymer from which the ionomer is made can be neutralized without losing the processibility and properties of elongation and toughness.

[0035] The melt-processible, highly-neutralized polyester copolymer ionomer can be produced by the following:

[0036] (a) melt-blending (1) polyester copolymer(s) or melt-processible ionomer(s) thereof (ionomers that are not neutralized to the level that they have become intractable, that is not melt-processible) with (1) one or more aliphatic, mono-functional, saturated or unsaturated organic acids having fewer than 36 carbon atoms or salts of the organic acids, and then concurrently or subsequently

[0037] (b) adding a sufficient amount of a cation source to increase the level of neutralization all the acid moieties (including those in the acid copolymer and in the organic acid) to greater than 90%, preferably near 100%, more preferably to 100%.

[0038] Preferably, highly-neutralized thermoplastics of the invention can be made by:

[0039] (a) melt-blending (1) polyester copolymer(s) or melt-processible ionomer(s) thereof that have their crystal-

linity disrupted by addition of a softening monomer or other means with (2) sufficient non-volatile, non-migratory agents.

[0040] (b) adding a sufficient amount of a cation source to increase the level of neutralization all the acid moieties (including those in the acid copolymer and in the organic acid if the non-volatile, non-migratory agent is an organic acid) to greater than 90%, preferably near 100%, more preferably to 100%.

[0041] The intermediate layers of the present invention may, optionally, comprise a durable, low deformation material such as metal, rigid plastics, or polymers re-enforced with high strength organic or inorganic fillers or fibers, or blends or composites thereof, as discussed below. Suitable plastics or polymers include, but not limited to, high cis- or trans-polybutadiene, one or more of partially or fully neutralized ionomers including those neutralized by a metal ion source wherein the metal ion is the salt of an organic acid, polyolefins including polyethylene, polypropylene, polybutylene and copolymers thereof including polyethylene acrylic acid or methacrylic acid copolymers, or a terpolymer of ethylene, a softening acrylate class ester such as methyl acrylate, n-butyl acrylate or iso-butyl-acrylate, and a carboxylic acid such as acrylic acid or methacrylic acid (e.g., terpolymers including polyethylene-methacrylic acid-n or iso-butyl acrylate and polyethylene-acrylic acid-methyl acrylate, polyethylene ethyl or methyl acrylate, polyethylene vinyl acetate, polyethylene glycidyl alkyl acrylates). Suitable polymers also include metallocene catalyzed polyolefins, polyesters, polyamides, non-ionomeric thermoplastic elastomers, copolyether-esters, copolyether-amides, EPR, EPDM, thermoplastic or thermosetting polyurethanes, polyureas, polyurethane ionomers, epoxies, polycarbonates, polybutadiene, polyisoprene, and blends thereof. In the case of metallocenes, the polymer may be cross-linked with a free radical source, such as peroxide, or by high radiation. Suitable polymeric materials also include those listed in U.S. Pat. Nos. 6,187,864, 6,232,400, 6,245,862, 6,290,611, 6,142,887, 5,902,855 and 5,306,760.

[0042] Preferably, when the intermediate layer is made with polybutadiene or other synthetic and natural rubber, the rubber composition is highly cross-linked with at least 50 phr of a suitable co-reaction agent, which includes a metal salt of diacrylate, dimethacrylate or mono methacrylate. Preferably, the co-reaction agent is zinc diacrylate. Highly cross-linked rubber compounds are discussed in commonly owned co-pending patent application entitled "Golf Ball and Method for Controlling the Spin Rate of Same" bearing U.S. Pat. No. 6,494,795. This discussion is incorporated herein by reference.

[0043] If desired, the golf ball can include highly rigid materials, such as certain metals, which include, but are not limited to, tungsten, steel, titanium, chromium, nickel, copper, aluminum, zinc, magnesium, lead, tin, iron, molybdenum and alloys thereof. Suitable highly rigid materials include those listed in U.S. Pat. No. 6,244,977. Fillers with very high specific gravity such as those disclosed in U.S. Pat. No. 6,287,217 can also be incorporated into the inner core. Suitable fillers and composites include, but not limited to, carbon including graphite, glass, boron carbide, polyethylene, polypropylene, silicon carbide, natural or synthetic silk.

[0044] In accordance to one embodiment of the present invention, the golf ball comprises at least two core layers, an innermost core and an outer core, and a cover. Preferably, outer core comprises a flexible, low compression, high COR

rubber composition discussed above, and inner core comprises a low deformation material discussed above. The hard, low deformation inner core resists deformation at high club speeds to maintain the COR at an optimal level, while the resilient outer layer provides high COR at slower club speeds and the requisite softness for short iron club play. The inventive ball, therefore, enjoys high initial velocity and high COR at high and low club head speeds associated, while maintaining a desirable soft feel and soft sound for greenside play.

[0045] Other rubber compounds for outer core may also include any low compression, high resilient polymers comprising natural rubbers, including cis-polyisoprene, trans-polyisoprene or balata, synthetic rubbers including 1,2-polybutadiene, cis-polybutadiene, trans-polybutadiene, polychloroprene, poly(norbornene), polyoctenamer and polypentenamer among other diene polymers. Outer core may comprise a plurality of layers, e.g., a laminate, where several thin flexible layers are plied or otherwise adhered together.

[0046] Preferably, the outer core is softer and has a lower compression than the inner core. The outer core preferably has a hardness of about 25 to about 70 on the Shore C scale. More preferably, the hardness is less than 60 on the Shore C scale.

[0047] One preferred way to achieve the difference in hardness between the inner core and the outer core is to make the inner core from un-foamed polymer, and to make the outer core from foamed polymer selected from the suitable materials disclosed herein. Alternatively, the outer core may be made from these suitable materials having their specific gravity reduced. In this embodiment the inner and outer core can be made from the same polymer or polymeric composition.

[0048] Preferably, outer core layer has a thickness from about 0.001 inches to about 0.100 inches, preferably from about 0.010 inches to about 0.050 inches and more preferably from about 0.015 inches to about 0.035 inches. Preferably, the overall core diameter is greater than about 1.50 inches, preferably greater than about 1.580 inches, and more preferably greater than about 1.60 inches. The inner core may have any dimension so long as the overall core diameter has the preferred dimensions listed above.

[0049] The cover should be tough, cut-resistant, and selected from conventional materials used as golf ball covers based on the desired performance characteristics. The cover may be comprised of one or more layers. Cover materials such as ionomer resins, blends of ionomer resins, thermoplastic or thermoset urethane, and balata, can be used as known in the art.

[0050] The cover is preferably a resilient, non-reduced specific gravity layer. Suitable materials include any material that allows for tailoring of ball compression, coefficient of restitution, spin rate, etc. and are disclosed in U.S. Pat. Nos. 6,419,535, 6,152,834, 5,919,100 and 5,885,172. Ionomers, ionomer blends, thermosetting or thermoplastic polyurethanes, metallocenes, polyurethanes, polyureas (and hybrids thereof), are the preferred materials. The cover can be manufactured by a casting method, reaction injection molded, injected or compression molded, sprayed or dipped method. Preferably the cover is cast about the core.

[0051] In a preferred embodiment, the golf ball includes an intermediate layer, as either an outer core layer or an inner cover, in addition to the outer cover. As disclosed in the U.S. Pat. Nos. 5,885,172 and 6,132,324, which are incorporated herein by reference in their entireties, outer cover layer is

made from a soft thermoset material, such as cast polyurethane or polyurea, and inner cover is made from an ionomeric material, preferably including at least two ionomers.

[0052] When the intermediate layer is an inner cover layer, it is preferably formed from a high flexural modulus material which contributes to the low spin, distance characteristics of the presently claimed balls when they are struck for long shots (e.g. driver or long irons). Specifically, the inner cover layer materials have a Shore D hardness of about 55 or greater, preferably about 55-70 and most preferably about 60-70. The flexural modulus of intermediate cover layer is at least about 50,000 psi, preferably about 50,000 psi to about 150,000 psi and most preferably about 75,000 psi to about 125,000 psi. In the preferred embodiment, the intermediate layer has a thickness of from about 0.1 inches to about 0.5 inches, more preferably between about 0.11 inches and about 0.12 inches, and most preferably between about 0.115 inches and about 0.119 inches. In another thin-layer embodiment, the thickness of the intermediate layer can range from about 0.020 inches to about 0.045 inches, preferably about 0.030 inches to about 0.040 inches and most preferably about 0.035 inches.

[0053] Outer cover layer is formed preferably from a relatively soft thermoset material in order to replicate the soft feel and high spin play characteristics of a balata ball for "short game" shots. In particular, the outer cover layer should have Shore D hardness of less than 65 or from about 40 to about 64, preferably 40-60 and most preferably 40-50. Additionally, the materials of the outer cover layer must have a degree of abrasion resistance in order to be suitable for use as a golf ball cover. The outer cover layer of the present invention can comprise any suitable thermoset or thermoplastic material, preferably which is formed from a castable reactive liquid material. The preferred materials for the outer cover layer include, but are not limited to, thermoset urethanes and polyurethanes, thermoset urethane ionomers and thermoset urethane epoxies. Examples of suitable polyurethane ionomers are disclosed in U.S. Pat. No. 5,692,974 entitled "Golf Ball Covers," the disclosure of which is hereby incorporated by reference in its entirety in the present application. Thermoset polyurethanes and polyureas are preferred for the outer cover layers of the balls of the present invention.

[0054] In accordance with another embodiment of the present invention, the golf ball comprises a relatively small, low compression, high COR inner core. The diameter of the inner core (or center) is preferably less than 1.40 inches or smaller, more preferably 0.8 inches to about 1.4 inches, and most preferably from about 1.3 inches to about 1.4 inches. The desired thickness of either the core (center) or intermediate layer can be selected in conjunction with the flexural modulus of the material of the layers and the desired overall compression of the ball and deformation of the ball.

[0055] Most preferably, inner core is formed from a rubber composition containing a polyester ionomer compound. In accordance to one aspect of the second embodiment, the rubber compound preferably is a high cis- or trans- polybutadiene and has a viscosity of about 40 Mooney to about 60 Mooney. The core has a hardness of greater than about 70 on the Shore C scale, and preferably greater than 80 on the Shore C scale. The core also has a compression of less than about 60 Atti, and more preferably less than about 50 Atti. The resulting core exhibits a COR of at least about 0.790, and most preferably at least 0.800 at 125 ft/s. Other suitable polymers for inner core include a polyethylene copolymer, EPR, EPDM, a metallocene catalyzed polymer or any of the mate-

rials discussed above in connection with outer core discussed above, so long as the preferred compression, hardness and COR are met.

[0056] Inner core may be encased by outer core layers comprising the same materials or different compositions than inner core. These outer core layers may be laminated together. Each of the laminate layers preferably has a thickness from about 0.001 inches to about 0.100 inches and more preferably from about 0.010 inches to about 0.050 inches.

[0057] Preferably, the intermediate layer is made from a low deformation polymeric material, such as a polyester ionomer, including low and high acid ionomer, any partially or fully neutralized ionomer or any thermoplastic or thermosetting polymer. The intermediate layer preferably has a flexural modulus of greater than 50,000 psi and more preferably greater than 75,000 psi. Among the preferred materials are hard, high flexural modulus ionomer resins and blends thereof. Additionally, other suitable mantle materials (as well as core and cover materials) are disclosed in U.S. Pat. No. 5,919,100 and international publications WO 00/23519 and WO 01/29129. These disclosures are incorporated by reference herein in their entireties. One particularly suitable material disclosed in WO 01/29129 is a melt processible composition comprising a highly neutralized ethylene copolymer and one or more aliphatic, mono-functional organic acids having fewer than 36 carbon atoms of salts thereof, wherein greater than 90% of all the acid of the ethylene copolymer is neutralized.

[0058] These ionomers are obtained by providing a cross metallic bond to polymers of mono-olefin with at least one member selected from the group consisting of unsaturated mono- or di-carboxylic acids having 3 to 12 carbon atoms and esters thereof (the polymer contains 1 to 50% by weight of the unsaturated mono- or di-carboxylic acid and/or ester thereof). More particularly, such acid-containing ethylene copolymer ionomer component includes E/X/Y copolymers where E is ethylene, X is a softening comonomer such as acrylate or methacrylate present in 0-50 weight percent of the polymer (preferably 0-25 wt. %, most preferably 0-20 wt. %), and Y is acrylic or methacrylic acid present in 5-35 weight percent of the polymer (preferably at least about 16 wt. %, more preferably at least about 16-35 wt. %, most preferably at least about 16-20 wt. %), wherein the acid moiety is neutralized 1-90% (preferably at least 40%, most preferably at least about 60%) to form an ionomer by a cation such as lithium*, sodium*, potassium, magnesium*, calcium, barium, lead, tin, zinc* or aluminum (*=preferred), or a combination of such cations. Specific acid-containing ethylene copolymers include ethylene/acrylic acid, ethylene/methacrylic acid, ethylene/acrylic acid/n-butyl acrylate, ethylene/methacrylic acid/n-butyl acrylate, ethylene/methacrylic acid/iso-butyl acrylate, ethylene/acrylic acid/iso-butyl acrylate, ethylene/methacrylic acid/n-butyl methacrylate, ethylene/acrylic acid/methyl methacrylate, ethylene/acrylic acid/methyl acrylate, ethylene/methacrylic acid/methyl acrylate, ethylene/methacrylic acid/methyl methacrylate, and ethylene/acrylic acid/n-butyl methacrylate. Preferred acid containing ethylene copolymers include ethylene/methacrylic acid, ethylene/acrylic acid, ethylene/methacrylic acid/n-butyl acrylate, ethylene/acrylic acid/n-butyl acrylate, ethylene/methacrylic acid/methyl acrylate and ethylene/acrylic acid/methyl acrylate copolymers. The most preferred acid-containing ethylene copolymers are ethylene/methacrylic acid, ethylene/acrylic acid, ethylene/(meth)acrylic acid/n-butyl acrylate,

ethylene/(meth)acrylic acid/ethyl acrylate, and ethylene/(meth)acrylic acid/methyl acrylate copolymers.

[0059] The manner in which the ionomers are made is well known in the art as described in e.g., U.S. Pat. No. 3,262,272. Such ionomer resins are commercially available from DuPont Co. under the tradename SURLYN® and from Exxon under the tradename IOTEK®. Some particularly suitable SURLYNs® include SURLYN® 8140 (Na) and SURLYN® 8546 (Li), which have a methacrylic acid content of about 19%.

[0060] Other suitable mantle materials include the low deformation materials described above and any hard, high flexural modulus, resilient material that is compatible with the other materials of the golf ball. Examples of other suitable inner cover materials include thermoplastic or thermoset polyurethanes, thermoplastic or thermoset polyetheresters or polyetheramides, thermoplastic or thermoset polyester, a dynamically vulcanized elastomer, a functionalized styrenebutadiene elastomer, a metallocene polymer or blends thereof.

[0061] Suitable thermoplastic polyetheresters include materials, which are commercially available from DuPont under the tradename HYTREL®.

[0062] Another suitable material for the intermediate layer is a high stiffness, highly neutralized ionomer having a durometer hardness of at least about 50 on the Shore D scale and a flexural modulus of at least 50,000 psi. The flexural modulus ranges from about 50,000 psi to about 150,000 psi. The hardness ranges from about 55 to about 80 Shore D, more preferably about 55 to about 70 Shore D. This ionomer, preferably at least two ionomers, may be blended with a lowly neutralized ionomers having an acid content of 5 to 25%, and may be blended with non-ionomeric polymers or compatibilizers (e.g., glycidyl or maleic anhydride), so long as the preferred hardness and flexural modulus are satisfied. Examples of highly neutralized ionomers are disclosed in commonly owned, U.S. Pat. No. 6,756,436. This application is incorporated herein by reference.

[0063] In one preferred embodiment, this suitable material is a blend of a fatty acid salt highly neutralized polymer, such as a melt processible composition comprising a highly neutralized ethylene copolymer and one or more aliphatic, monofunctional organic acids having fewer than 36 carbon atoms of salts thereof, wherein greater than 90% of all the acid of the ethylene copolymer is neutralized, and a high stiffness partially neutralized ionomer, such as those commercially available as Surlyn® 8945, 7940, 8140 and 9120, among others. This blend has hardness in the range of about 65 to about 75 on the Shore D scale.

[0064] The intermediate layer may also comprise a laminated layer, if desired. For example, the intermediate layer may comprise a laminate comprising four layers: a polyamide layer having a flexural modulus of about 200,000 psi, a terpolymer ionomer or un-neutralized acid terpolymer having a flexural modulus of about 30,000 psi, a low acid ionomer having a flexural modulus of about 60,000 psi and a high acid ionomer having a flexural modulus of about 70,000 psi. The composite flexural modulus of the four-layer laminate is about 90,000 psi or approximately the average of the flexural modulus of the four layers, assuming that the thickness of each layer is about the same.

[0065] In a preferred embodiment, inner core, if present, has a diameter of about 0.800 to about 1.400 inches, more preferably about 1.3 to about 1.4 inches, a compression of about 44 or less, and a COR of about 0.800. The intermediate

layer comprises at least two ionomers having a combined flexural modulus of at least about 50,000 psi, and has a thickness of at least about 0.110 inches, preferably between about 0.11 inches and about 0.12 inches. The cover is preferably a cast polyurethane or polyurea having a hardness of about 40 to about 60 Shore D. The core compression is preferably about 44 or less, and the combination of core and intermediate layer has a compression of from about 70 to about 100.

[0066] The core preferably comprises a single solid layer. Alternatively, the core may comprise multiple layers. Preferably, its diameter is about 1.400 inches or less, more preferably between about 0.8 inches and about 1.4 inches, most preferably between about 1.3 inches and about 1.4 inches. The core has a COR of about 0.770 or greater, more preferably about 0.800 or greater, and most preferably about 0.820 or greater, so as to give the ball a COR of at least 0.800 and more preferably in the range of about 0.805 to about 0.820.

[0067] In a preferred embodiment, intermediate cover layer and outer cover layer are similar to the inner cover layer and the outer cover layer of cover, respectively, for progressive performance. For example, outer cover layer is made from a soft, thermosetting polymer, such as cast polyurethane, and intermediate cover layer is made from a rigid ionomer or similar composition having hardness of at least 55 on the Shore D scale and flexural modulus of at least 55,000 psi.

[0068] The total thickness of the cover is preferably less than 0.125 inches. Innermost layer preferably is about 0.005 inches to about 0.100 inches thick, more preferably 0.010 inches to about 0.090 inches, and most preferably about 0.015 inches to about 0.070 inches. Intermediate cover layer preferably is about 0.010 inches to about 0.050 inches thick, and outer cover layer preferably is about 0.020 inches to about 0.040 inches thick.

[0069] Golf balls made in accordance to the present invention and disclosed above have a compression of greater than about 60 Atti, more preferably greater than about 80 and even more preferably greater than about 90 Atti. These balls exhibit COR of at least 0.80 at 125 feet per second and more preferably at least 0.81 at 125 feet per second. These balls also exhibit COR of at least 0.75 at 160 feet per second and more preferably at least 0.76 at 160 feet per second.

[0070] 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. For instance, the ball may have an icosahedron-based pattern, such as described in U.S. Pat. No. 4,560,168, or an octahedral-based dimple pattern as described in U.S. Pat. No. 4,960,281. Alternatively, the dimple pattern can be arranged according to phyllotactic patterns, such as described in U.S. Pat. No. 6,338,684, which is incorporated herein in its entirety.

[0071] Dimple patterns may also be based on Archimedean patterns including a truncated octahedron, a great rhombicuboctahedron, a truncated dodecahedron, and a great rhombicosidodecahedron, wherein the pattern has a non-linear parting line, as disclosed in U.S. Pat. No. 6,705,959, which is incorporated by reference herein. The golf balls of the present invention may also be covered with non-circular shaped dimples, i.e., amorphous shaped dimples, as disclosed in U.S. Pat. No. 6,409,615, which is incorporated in its entirety by reference herein.

[0072] Dimple patterns that provide a high percentage of surface coverage are preferred, and are well known in the art.

For example, U.S. Pat. Nos. 5,562,552, 5,575,477, 5,957,787, 5,249,804, and 4,925,193 disclose geometric patterns for positioning dimples on a golf ball. In one embodiment, the golf balls of the invention have a dimple coverage of the surface area of the cover of at least about 60 percent, preferably at least about 65 percent, and more preferably at least 70 percent or greater. Dimple patterns having even higher dimple coverage values may also be used with the present invention. Thus, the golf balls of the present invention may have a dimple coverage of at least about 75 percent or greater, about 80 percent or greater, or even about 85 percent or greater.

[0073] In addition, a tubular lattice pattern, such as the one disclosed in U.S. Pat. No. 6,290,615, which is incorporated by reference in its entirety herein, may also be used with golf balls of the present invention. The golf balls of the present invention may also have a plurality of pyramidal projections disposed on the intermediate layer of the ball, as disclosed in U.S. Pat. No. 6,383,092, which is incorporated in its entirety by reference herein. The plurality of pyramidal projections on the golf ball may cover between about 20 percent to about 80 of the surface of the intermediate layer.

[0074] The total number of dimples on the ball, or dimple count, may vary depending such factors as the sizes of the dimples and the pattern selected. In general, the total number of dimples on the ball preferably is between about 100 to about 1000 dimples, although one skilled in the art would recognize that differing dimple counts within this range can significantly alter the flight performance of the ball. In one embodiment, the dimple count is about 380 dimples or greater, but more preferably is about 400 dimples or greater, and even more preferably is about 420 dimples or greater. In one embodiment, the dimple count on the ball is about 422 dimples. In some cases, it may be desirable to have fewer dimples on the ball. Thus, one embodiment of the present invention has a dimple count of about 380 dimples or less, and more preferably is about 350 dimples or less.

[0075] Dimple profiles revolving a catenary curve about its symmetrical axis may increase aerodynamic efficiency, provide a convenient way to alter the dimples to adjust ball performance without changing the dimple pattern, and result in uniformly increased flight distance for golfers of all swing speeds. Thus, catenary curve dimple profiles, as disclosed in U.S. Pat. No. 6,796,912, which is incorporated in its entirety by reference herein, is contemplated for use with the golf balls of the present invention.

[0076] The golf balls of the present invention may be painted, coated, or surface treated for further benefits. For example, golf balls covers frequently contain a fluorescent material and/or a dye or pigment to achieve the desired color characteristics. A golf ball of the invention may also be treated with a base resin paint composition. In addition, the golf ball may be coated with a composition including a whitening agent.

[0077] In one embodiment, the golf balls of the invention may be UV cured. Suitable methods for UV curing are disclosed in U.S. Pat. Nos. 6,500,495, 6,248,804, and 6,099,415, the entire disclosures of which are incorporated by reference herein. In one embodiment, the top coat is UV curable. In another embodiment, the ink is UV curable and may be used as a paint layer or as a discrete marking tool for logos and indicia.

[0078] In addition, trademarks or other indicia may be stamped, i.e., pad-printed, on the outer surface of the ball cover, and the stamped outer surface is then treated with at

least one clear coat to give the ball a glossy finish and protect the indicia stamped on the cover.

[0079] Protective and decorative coating materials, as well as methods of applying such materials to the surface of a golf ball cover are well known in the golf ball art. Generally, such coating materials comprise urethanes, urethane hybrids, epoxies, polyesters and acrylics. If desired, more than one coating layer can be used. The coating layer(s) may be applied by any suitable method known to those of ordinary skill in the art. In one embodiment, the coating layer(s) is applied to the golf ball cover by an in-mold coating process, such as described in U.S. Pat. No. 5,849,168, which is incorporated in its entirety by reference herein.

[0080] The present invention can be used in forming golf balls of any desired size. While "The Rules of Golf" by the USGA dictates that the size of a competition golf ball be more than 1.680 inches in diameter, golf balls of any size can be used for leisure golf play. Therefore, while the preferred diameter of the golf balls is at least 1.680 inches to about 1.800 inches, golf balls of any size.

[0081] The properties such as hardness, modulus, core diameter, intermediate layer thickness and cover layer thickness of the golf balls of the present invention have been found to effect play characteristics such as spin, initial velocity and feel of the present golf balls. For example, the flexural and/or tensile modulus of the intermediate layer are believed to have an effect on the "feel" of the golf balls of the present invention.

[0082] Dimensions of golf ball components, i.e., thickness and diameter, may vary depending on the desired properties. For the purposes of the invention, any layer thickness may be employed. Non-limiting examples of the various embodiments outlined above are provided here with respect to layer dimensions.

[0083] The present invention relates to golf balls of any size. While USGA specifications limit the size of a competition golf ball to more than 1.68 inches in diameter, golf balls of any size can be used for leisure golf play. The preferred diameter of the golf balls is from about 1.68 inches to about 1.8 inches. The more preferred diameter is from about 1.68 inches to about 1.76 inches. A diameter of from about 1.68 inches to about 1.74 inches is most preferred, however diameters anywhere in the range of from 1.7 to about 1.95 inches can be used. Preferably, the overall diameter of the core and all intermediate layers is about 80 percent to about 98 percent of the overall diameter of the finished ball.

[0084] The core may have a diameter ranging from about 0.09 inches to about 1.65 inches. In one embodiment, the diameter of the core of the present invention is about 1.2 inches to about 1.630 inches. In another embodiment, the diameter of the core is about 1.3 inches to about 1.6 inches, preferably from about 1.39 inches to about 1.6 inches, and more preferably from about 1.5 inches to about 1.6 inches. In yet another embodiment, the core has a diameter of about 1.55 inches to about 1.65 inches.

[0085] The core of the golf ball may also be extremely large in relation to the rest of the ball. For example, in one embodiment, the core makes up about 90 percent to about 98 percent of the ball, preferably about 94 percent to about 96 percent of the ball. In this embodiment, the diameter of the core is preferably about 1.54 inches or greater, preferably about 1.55 inches or greater. In one embodiment, the core diameter is about 1.59 inches or greater. In another embodiment, the diameter of the core is about 1.64 inches or less.

[0086] When the core includes an inner core layer and an outer core layer, the inner core layer is preferably about 0.9 inches or greater and the outer core layer preferably has a thickness of about 0.1 inches or greater. In one embodiment, the inner core layer has a diameter from about 0.09 inches to about 1.2 inches and the outer core layer has a thickness from about 0.1 inches to about 0.8 inches. In yet another embodiment, the inner core layer diameter is from about 0.095 inches to about 1.1 inches and the outer core layer has a thickness of about 0.20 inches to about 0.03 inches.

[0087] The cover typically has a thickness to provide sufficient strength, good performance characteristics, and durability. In one embodiment, the cover thickness is from about 0.02 inches to about 0.35 inches. The cover preferably has a thickness of about 0.02 inches to about 0.12 inches, preferably about 0.1 inches or less. When the compositions of the invention are used to form the outer cover of a golf ball, the cover may have a thickness of about 0.1 inches or less, preferably about 0.07 inches or less. In one embodiment, the outer cover has a thickness from about 0.02 inches to about 0.07 inches. In another embodiment, the cover thickness is about 0.05 inches or less, preferably from about 0.02 inches to about 0.05 inches. In yet another embodiment, the outer cover layer of such a golf ball is between about 0.02 inches and about 0.045 inches. In still another embodiment, the outer cover layer is about 0.025 to about 0.04 inches thick. In one embodiment, the outer cover layer is about 0.03 inches thick.

[0088] The range of thicknesses for an intermediate layer of a golf ball is large because of the vast possibilities when using an intermediate layer, i.e., as an outer core layer, an inner cover layer, a wound layer, a moisture/vapor barrier layer. When used in a golf ball of the invention, the intermediate layer, or inner cover layer, may have a thickness about 0.3 inches or less. In one embodiment, the thickness of the intermediate layer is from about 0.002 inches to about 0.1 inches, preferably about 0.01 inches or greater. In one embodiment, the thickness of the intermediate layer is about 0.09 inches or less, preferably about 0.06 inches or less. In another embodiment, the intermediate layer thickness is about 0.05 inches or less, more preferably about 0.01 inches to about 0.045 inches. In one embodiment, the intermediate layer, thickness is about 0.02 inches to about 0.04 inches. In another embodiment, the intermediate layer thickness is from about 0.025 inches to about 0.035 inches. In yet another embodiment, the thickness of the intermediate layer is about 0.035 inches thick. In still another embodiment, the inner cover layer is from about 0.03 inches to about 0.035 inches thick. Varying combinations of these ranges of thickness for the intermediate and outer cover layers may be used in combination with other embodiments described herein.

[0089] The ratio of the thickness of the intermediate layer to the outer cover layer is preferably about 10 or less, preferably from about 3 or less. In another embodiment, the ratio of the thickness of the intermediate layer to the outer cover layer is about 1 or less. The core and intermediate layer(s) together form an inner ball preferably having a diameter of about 1.48 inches or greater for a 1.68-inch ball. In one embodiment, the inner ball of a 1.68-inch ball has a diameter of about 1.52 inches or greater. In another embodiment, the inner ball of a 1.68-inch ball has a diameter of about 1.66 inches or less. In yet another embodiment, a 1.72-inch (or more) ball has an inner ball diameter of about 1.50 inches or greater. In still another embodiment, the diameter of the inner ball for a 1.72-inch ball is about 1.70 inches or less.

[0090] Most golf balls consist of layers having different hardness, e.g., hardness gradients, to achieve desired performance characteristics. The present invention contemplates golf balls having hardness gradients between layers, as well as those golf balls with layers having the same hardness.

[0091] It should be understood, especially to one of ordinary skill in the art, that there is a fundamental 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 of which the hardness is to be measured. Hardness, when measured directly on a golf ball (or other spherical surface) is a completely different measurement and, therefore, results in a different hardness value. This difference results from 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. It should also be understood that the two measurement techniques are not linearly related and, therefore, one hardness value cannot easily be correlated to the other.

[0092] The cores of the present invention may have varying hardness depending on the particular golf ball construction. In one embodiment, the core hardness is at least about 15 Shore A, preferably about 30 Shore A, as measured on a formed sphere. In another embodiment, the core has a hardness of about 50 Shore A to about 90 Shore D. In yet another embodiment, the hardness of the core is about 80 Shore D or less. Preferably, the core has a hardness about 30 to about 65 Shore D, and more preferably, the core has a hardness about 35 to about 60 Shore D.

[0093] When a polybutadiene reaction product is incorporated into a core, the core may have a hardness gradient, i.e., a first hardness at a first point, i.e., at an interior location, and a second hardness at a second point, i.e., at an exterior surface, as measured on a molded sphere. In one embodiment, the second hardness is at least about 6 percent greater than the first hardness, preferably about 10 percent greater than the first hardness. In other embodiments, the second hardness is at least about 20 percent greater or at least about 30 percent greater, than the first hardness.

[0094] For example, the interior of the core may have a first hardness of about 45 Shore C to about 60 Shore C and the exterior surface of the core may have a second hardness of about 65 Shore C to about 75 Shore C. In one golf ball formulated according to the invention, the first hardness was about 51 Shore C and a second hardness was about 71 Shore C, providing a hardness difference of greater than 20 percent.

[0095] In one embodiment, however, the core has a substantially uniform hardness throughout. Thus, in this aspect, the first and second hardness preferably differ by about 5 percent or less, more preferably about 3 percent or less, and even more preferably by about 2 percent or less. In another embodiment, the hardness is uniform throughout the component.

[0096] The intermediate layer(s) of the present invention may also vary in hardness depending on the specific construction of the ball. In one embodiment, the hardness of the intermediate layer is about 30 Shore D or greater. In another embodiment, the hardness of the intermediate layer is about 90 Shore D or less, preferably about 80 Shore D or less, and more preferably about 70 Shore D or less. In yet another embodiment, the hardness of the intermediate layer is about

50 Shore D or greater, preferably about 55 Shore D or greater. In one embodiment, the intermediate layer hardness is from about 55 Shore D to about 65 Shore D. The intermediate layer may also be about 65 Shore D or greater.

[0097] When the intermediate layer is intended to be harder than the core layer, the ratio of the intermediate layer hardness to the core hardness preferably about 2 or less. In one embodiment, the ratio is about 1.8 or less. In yet another embodiment, the ratio is about 1.3 or less.

[0098] As with the core and intermediate layers, the cover hardness may vary depending on the construction and desired characteristics of the golf ball. The ratio of cover hardness to inner ball hardness is a primary variable used to control the aerodynamics of a ball and, in particular, the spin of a ball. In general, the harder the inner ball, the greater the driver spin and the softer the cover, the greater the driver spin.

[0099] For example, when the intermediate layer is intended to be the hardest point in the ball, e.g., about 50 Shore D to about 75 Shore D, the cover material may have a hardness of about 20 Shore D or greater, preferably about 25 Shore D or greater, and more preferably about 30 Shore D or greater, as measured on the slab. In another embodiment, the cover itself has a hardness of about 30 Shore D or greater. In particular, the cover may be from about 30 Shore D to about 60 Shore D. In one embodiment, the cover has a hardness of about 40 Shore D to about 65 Shore D. In another embodiment, the cover has a hardness less than about 45 Shore D, preferably less than about 40 Shore D, and more preferably about 25 Shore D to about 40 Shore D. In one embodiment, the cover has a hardness from about 30 Shore D to about 40 Shore D.

[0100] In this embodiment when the outer cover layer is softer than the intermediate layer or inner cover layer, the ratio of the Shore D hardness of the outer cover material to the intermediate layer material is about 0.8 or less, preferably about 0.75 or less, and more preferably about 0.7 or less. In another embodiment, the ratio is about 0.5 or less, preferably about 0.45 or less.

[0101] In yet another embodiment, the ratio is about 0.1 or less when the cover and intermediate layer materials have hardness that are substantially the same. When the hardness differential between the cover layer and the intermediate layer is not intended to be as significant, the cover may have a hardness of about 55 Shore D to about 65 Shore D. In this embodiment, the ratio of the Shore D hardness of the outer cover to the intermediate layer is about 1.0 or less, preferably about 0.9 or less.

[0102] The cover hardness may also be defined in terms of Shore C. For example, the cover may have a hardness of about 70 Shore C or greater, preferably about 80 Shore C or greater. In another embodiment, the cover has a hardness of about 95 Shore C or less, preferably about 90 Shore C or less.

[0103] In another embodiment, the cover layer is harder than the intermediate layer. In this design, the ratio of Shore D hardness of the cover layer to the intermediate layer is about 1.33 or less, preferably from about 1.14 or less.

[0104] When a two-piece ball is constructed, the core may be softer than the outer cover. For example, the core hardness may range from about 30 Shore D to about 50 Shore D, and the cover hardness may be from about 50 Shore D to about 80 Shore D. In this type of construction, the ratio between the cover hardness and the core hardness is preferably about 1.75 or less. In another embodiment, the ratio is about 1.55 or less. Depending on the materials, for example, if a composition of

the invention is acid-functionalized wherein the acid groups are at least partially neutralized, the hardness ratio of the cover to core is preferably about 1.25 or less.

[0105] Compression values are dependent on the diameter of the component being measured. The Atti compression of the core, or portion of the core, of golf balls prepared according to the invention is preferably less than about 80, more preferably less than about 75. As used herein, the terms "Atti compression" or "compression" are defined as the deflection of an object or material relative to the deflection of a calibrated spring, as measured with an Atti Compression Gauge, that is commercially available from Atti Engineering Corp. of Union City, N.J. Atti compression is typically used to measure the compression of a golf ball. In another embodiment, the core compression is from about 40 to about 80, preferably from about 50 to about 70. In yet another embodiment, the core compression is preferably below about 50, and more preferably below about 25, are within the scope of the present invention.

[0106] In an alternative, low compression embodiment, the core has a compression less than about 20, more preferably less than about 10, and most preferably, 0. As known to those of ordinary skill in the art, however, the cores generated according to the present invention may be below the measurement of the Atti Compression Gauge. In an embodiment where the core is hard, the compression may be about 90 or greater. In one embodiment, the compression of the hard core ranges from about 90 to about 100.

[0107] In one embodiment, golf balls of the invention preferably have an Atti compression of about 55 or greater, preferably from about 60 to about 120. In another embodiment, the Atti compression of the golf balls of the invention is at least about 40, preferably from about 50 to 120, and more preferably from about 60 to 100. In yet another embodiment, the compression of the golf balls of the invention is about 75 or greater and about 95 or less. For example, a preferred golf ball of the invention may have a compression from about 80 to about 95.

[0108] As used herein, the term "coefficient of restitution" (COR) is calculated by dividing the rebound velocity of the golf ball by the incoming velocity when a golf ball is shot out of an air cannon. The COR testing is conducted over a range of incoming velocities and determined at an inbound velocity of 125 ft/s.

[0109] There is currently no USGA limit on the COR of a golf ball, but the initial velocity of the golf ball cannot exceed 250 \pm 5 feet/second (ft/s). Thus, in one embodiment, the initial velocity is about 245 ft/s or greater and about 255 ft/s or less. In another embodiment, the initial velocity is about 250 ft/s or greater. In one embodiment, the initial velocity is about 253 ft/s to about 254 ft/s. In yet another embodiment, the initial velocity is about 255 ft/s. While the current rules on initial velocity require that golf ball manufacturers stay within the limit, one of ordinary skill in the art would appreciate that the golf ball of the invention would readily convert into a golf ball with initial velocity outside of this range.

[0110] As a result, of the initial velocity limitation set forth by the USGA, the goal is to maximize COR without violating the 255 ft/s limit. In a one-piece solid golf ball, the COR will depend on a variety of characteristics of the ball, including its composition and hardness. For a given composition, COR will generally increase as hardness is increased. In a two-piece solid golf ball, e.g., a core and a cover, one of the purposes of the cover is to produce a gain in COR over that of

the core. When the contribution of the core to high COR is substantial, a lesser contribution is required from the cover. Similarly, when the cover contributes substantially to high COR of the ball, a lesser contribution is needed from the core.

[0111] The present invention contemplates golf balls having CORs from about 0.7 to about 0.85. In one embodiment, the COR is about 0.75 or greater, preferably about 0.78 or greater. In another embodiment, the ball has a COR of about 0.8 or greater.

[0112] In addition, the inner ball preferably has a COR of about 0.780 or more. In one embodiment, the COR is about 0.790 or greater.

[0113] As known to those of ordinary skill in the art, the spin rate of a golf ball will vary depending on the golf ball construction. In a multilayer ball, e.g., a core, an intermediate layer, and a cover, wherein the cover is formed from the polyurea or polyurethane compositions of the invention, the spin rate of the ball off a driver ("driver spin rate") is preferably about 2700 rpm or greater. In one embodiment, the driver spin rate is about 2800 rpm to about 3500 rpm. In another embodiment, the driver spin rate is about 2900 rpm to about 3400 rpm. In still another embodiment, the driver spin rate may be less than about 2700 rpm.

[0114] Two-piece balls made according to the invention may also have driver spin rates of 2700 rpm and greater. In one embodiment, the driver spin rate is about 2700 rpm to about 3300 rpm. Wound balls made according to the invention may have similar spin rates.

[0115] Methods of determining the spin rate should be well understood by those of ordinary skill in the art. Examples of methods for determining the 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 in their entirety.

[0116] Accordingly, it is preferable that the golf balls of the present invention have an intermediate layer with a flexural modulus of about 500 psi to about 500,000 psi. More preferably, the flexural modulus of the intermediate layer is about 1,000 psi to about 250,000 psi. Most preferably, the flexural modulus of the intermediate layer is about 2,000 psi to about 200,000 psi.

[0117] The flexural moduli of the cover layer is preferably about 2,000 psi or greater, and more preferably about 5,000 psi or greater. In one embodiment, the flexural modulus of the cover is from about 10,000 psi to about 150,000 psi. More preferably, the flexural modulus of the cover layer is about 15,000 psi to about 120,000 psi. Most preferably, the flexural modulus of the cover layer is about 18,000 psi to about 110,000 psi. In another embodiment, the flexural moduli of the cover layer is about 100,000 psi or less, preferably about 80,000 or less, and more preferably about 70,000 psi or less. In one embodiment, when the cover layer has a hardness of about 50 Shore D to about 60 Shore D, the cover layer preferably has a flexural modulus of about 55,000 psi to about 65,000 psi.

[0118] In one embodiment, the ratio of the flexural modulus of the intermediate layer to the cover layer is about 0.003 to about 50. In another embodiment, the ratio of the flexural modulus of the intermediate layer to the cover layer is about 0.006 to about 4.5. In yet another embodiment, the ratio of the flexural modulus of the intermediate layer to the cover layer is about 0.11 to about 4.5.

[0119] As briefly discussed above, the compositions of the invention are used in a golf ball with multiple cover layers having essentially the same hardness, but differences in flex-

ural moduli. In this aspect of the invention, the difference between the flexural moduli of the two cover layers is preferably about 5,000 psi or less. In another embodiment, the difference in flexural moduli is about 500 psi or greater. In yet another embodiment, the difference in the flexural moduli between the two cover layers, wherein at least one is reinforced is about 500 psi to about 10,000 psi, preferably from about 500 psi to about 5,000 psi. In one embodiment, the difference in flexural moduli between the two cover layers formed of unreinforced or unmodified materials is about 1,000 psi to about 2,500 psi.

[0120] The specific gravity of a cover or intermediate layer including the polyurethane or polyurea compositions of the invention is preferably at least about 0.7.

[0121] While it is apparent that the invention disclosed herein is well calculated to fulfill the objects stated above, it will be appreciated that numerous modifications and embodiments may be devised by those skilled in the art. For example, while golf balls and golf ball components are used as examples for articles incorporating the compositions of the invention, other golf equipment may be formed from the compositions of the invention. In one embodiment, at least a portion of a golf shoe is formed from the composition of the invention. In another embodiment, the composition of the invention is used to form at least a portion of a golf club, e.g., a putter insert. Therefore, it is intended that the appended claims cover all such modifications and embodiments that fall within the true spirit and scope of the present invention.

What is claimed is:

1. A golf ball comprising:
a core, and at least one layer over the core, wherein the core or the at least one layer comprises a material formed from a composition comprising a partially or fully neutralized polyester ionomer.
2. The golf ball of claim 1, wherein the at least one layer comprises a cover.
3. The golf ball of claim 1, wherein the at least one layer comprises an outer core layer and a cover.
4. The golf ball of claim 1, wherein the at least one layer comprises a core layer, at least one intermediate layer and a cover.
5. The golf ball of claim 1, wherein the at least one layer comprises at least one intermediate layer and a cover.
6. The golf ball of claim 1, wherein the polyester ionomer comprises a monomer containing an ionic moiety such as sulfonate or carboxylate.
7. The golf ball of claim 6, wherein the monomers comprise dimethyl phthalate, terephthalic acid, PTMEG, butane diol, isophthaloyl chloride, polybutadiene diol, dimethyl sebacate, 3-sodium sulfophthalic acid, 5-sulfoisophthalate, or phthalic anhydride.
8. The golf ball of claim 6, wherein the ionic moiety comprises being neutralized with a counter-ion selected from the group consisting of Li, Na, K, Mg, Ca, Sr, Zn, Al, ammonium and alkylammonium metal cations.
9. The golf ball of claim 8, wherein the comonomer comprises a viscosity reducer or flow modifier.
10. The golf ball of claim 1, wherein the cover further comprises partially- or fully-neutralized ionomers, metal-locene-catalyzed polymers, single-site catalyzed polymers, polyesters, polyethers, balata, crosslinked diene rubbers, styrene block copolymers, polyurethanes, polyureas, polyurethane-ureas, polyurea-urethanes, or non-ionic fluoropolymers.

11. The golf ball of claim **10**, wherein the cover comprises a thermoset polymer having a Shore D hardness of 60 or less.

12. The golf ball of claim **1**, wherein the combination of the core and the at least one layer results in the golf ball having a coefficient of restitution of 0.810 to 0.825 when measured at an incoming velocity of 125 ft/s.

13. A golf ball comprising:

a core, at least one intermediate layer, and a cover, wherein the core or the intermediate layer or the cover least comprises a material formed from a composition comprising a partially or fully neutralized polyester ionomer compound.

14. The golf ball of claim **13**, wherein the core is formed from a rubber composition containing a fully or partially neutralized polyester ionomer compound, the core having a Shore C hardness greater than 80, a compression of less than about 50, a COR of at least 0.800 at 125 feet per second.

15. The golf ball of claim **13**, wherein the cover is formed from a fully or partially neutralized polyester ionomer compound, the cover having a Shore D hardness of 60 or less.

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