



- (51) **International Patent Classification:**
C08G 63/60 (2006.01) *C09K 19/38* (2006.01)
C08G 63/91 (2006.01)
- (21) **International Application Number:**
PCT/US2012/064750
- (22) **International Filing Date:**
13 November 2012 (13.11.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
- | | | |
|------------|-------------------------------|----|
| 61/559,822 | 15 November 2011 (15.11.2011) | US |
| 61/559,828 | 15 November 2011 (15.11.2011) | US |
| 61/599,077 | 15 February 2012 (15.02.2012) | US |
| 61/678,267 | 1 August 2012 (01.08.2012) | US |
| 61/678,285 | 1 August 2012 (01.08.2012) | US |
- (71) **Applicant:** TICONA LLC [US/US]; 8040 Dixie Highway, Florence, KY 41042 (US).
- (72) **Inventor:** KIM, Young, Shin; 3940 Pondhill Court, Erlanger, KY 41018 (US).
- (74) **Agent:** JOHNSTON, Jason, W.; Dority & Manning, P.A., P.O. Box 1449, Greenville, SC 29602-1449 (US).
- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM,

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

- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) **Title:** LIQUID CRYSTALLINE POLYMER COMPOSITION FOR HIGH VOLTAGE ELECTRONIC COMPONENTS

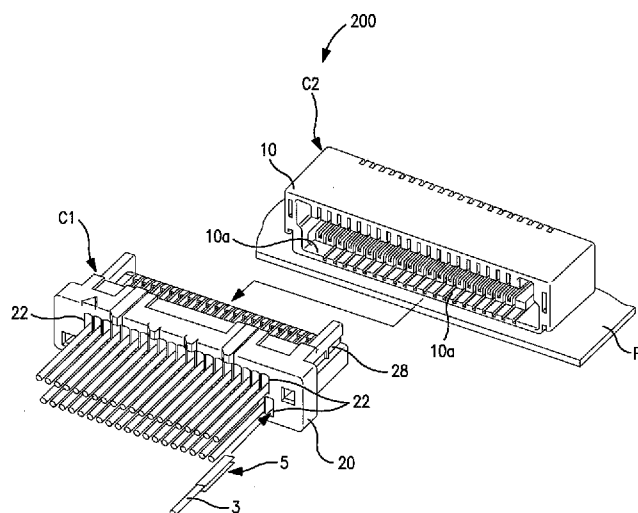


FIG. 1

(57) **Abstract:** A liquid crystalline polymer composition having a relatively high comparative tracking index ("CTI") is provided. The present inventors have discovered that high CTI values can be achieved through the use of inorganic particles in combination with a functional aromatic compound. While not fully understood, it is believed that the functional compound can react with the liquid crystalline polymer and create smaller degraded polymer chains. In combination with the inorganic particles, these smaller chains can potentially form insulated regions at the surface of the polymer that hinder the formation of conductive carbonaceous deposits during the tracking process, which could otherwise lead to failure during testing.

LIQUID CRYSTALLINE POLYMER COMPOSITION FOR HIGH VOLTAGE ELECTRONIC COMPONENTS

Related Applications

[0001] This application claims filing benefit of United States Provisional Patent Applications Serial Nos. 61/559, 822 and 61/559,828 filed on November 15, 2011; 61/599,077 filed on February 15, 2012; and 61/678,267 and 61/678,285 filed on August 1, 2012, which are incorporated herein in their entirety.

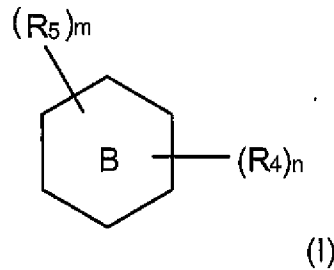
Background of the Invention

[0002] Electrical components often contain molded parts that are formed from liquid crystalline polymers due to their ability to form highly ordered structures. Several different challenges exist for successfully forming liquid crystalline polymer parts for electrical components. For instance, tracking is a phenomenon associated with the formation of permanent and progressive conducting paths on the surface of materials, usually by the combined effects of an electrical field and external surface pollution. Electrical tracking can occur when a damaged energized electrical part becomes wet, such as from electrolytes or condensation, and may lead to flash over and arcing that causes damage in the electrical part and potential catastrophic cascade failure. Unfortunately, most liquid crystalline polymers exhibit relatively poor electrical tracking properties, which can limit their use to only low and medium voltage applications.

[0003] As such, a need exists for a liquid crystalline polymer composition that can be used in high voltage applications.

Summary of the Invention

[0004] In accordance with one embodiment of the present invention, a polymer composition is disclosed that comprises from about 20 wt.% to about 90 wt.% of at least one thermotropic liquid crystalline polymer, from about 1 wt.% to about 60 wt.% of inorganic particles, and from about 0.001 wt.% to about 5 wt.% of at least one functional aromatic compound having the general structure provided below in Formula (I):



or a metal salt thereof, wherein,

ring B is a 6-membered aromatic ring wherein 1 to 3 ring carbon atoms are optionally replaced by nitrogen or oxygen, wherein each nitrogen is optionally oxidized, and wherein ring B may be optionally fused or linked to a 5- or 6-membered aryl, heteroaryl, cycloalkyl, or heterocyclyl;

R_4 is OH or COOH;

R_5 is acyl, acyloxy, acylamino, alkoxy, alkenyl, alkyl, amino, aryl, aryloxy, carboxyl, carboxyl ester, cycloalkyl, cycloalkyloxy, hydroxyl, halo, haloalkyl, heteroaryl, heteroaryloxy, heterocyclyl, or heterocycloxy;

m is from 0 to 4; and

n is from 1 to 3. The polymer composition has a comparative tracking index of about 225 volts or more, as determined in accordance with ASTM D-3638-12.

[0005] In accordance with another embodiment of the present invention, an electronic component is disclosed that comprises a polymer composition. The polymer composition comprises at least one thermotropic liquid crystalline polymer, inorganic particles, and at least one functional aromatic compound. The polymer composition has a comparative tracking index of about 225 volts or more, as determined in accordance with ASTM D-3638-12.

[0006] Other features and aspects of the present invention are set forth in greater detail below.

Brief Description of the Figures

[0007] A full and enabling disclosure of the present invention, including the best mode thereof to one skilled in the art, is set forth more particularly in the remainder of the specification, including reference to the accompanying figures, in which:

[0008] Fig. 1 is an exploded perspective view of one embodiment of a fine pitch electrical connector that may be formed according to the present invention;

[0009] Fig. 2 is a front view of opposing walls of the fine pitch electrical connector of Fig. 1;

[0010] Fig. 3 is a schematic illustration of one embodiment of an extruder screw that may be used to form the polymer composition of the present invention;

[0011] Figs. 4-5 are respective front and rear perspective views of an electronic component that can employ an antenna structure formed in accordance with one embodiment of the present invention; and

[0012] Figs. 6-7 are perspective and front views of a compact camera module ("CCM") that may be formed in accordance with one embodiment of the present invention.

Detailed Description

[0013] It is to be understood that the terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present invention.

[0014] "Alkyl" refers to monovalent saturated aliphatic hydrocarbyl groups having from 1 to 10 carbon atoms and, in some embodiments, from 1 to 6 carbon atoms. "C_{x-y}alkyl" refers to alkyl groups having from x to y carbon atoms. This term includes, by way of example, linear and branched hydrocarbyl groups such as methyl (CH₃), ethyl (CH₃CH₂), *n*-propyl (CH₃CH₂CH₂), isopropyl ((CH₃)₂CH), *n*-butyl (CH₃CH₂CH₂CH₂), isobutyl ((CH₃)₂CHCH₂), *sec*-butyl ((CH₃)(CH₃CH₂)CH), *t*-butyl ((CH₃)₃C), *n*-pentyl (CH₃CH₂CH₂CH₂CH₂), and neopentyl ((CH₃)₃CCH₂).

[0015] "Alkoxy" refers to the group -O-alkyl. Alkoxy includes, by way of example, methoxy, ethoxy, *n*-propoxy, isopropoxy, *n*-butoxy, *t*-butoxy, *sec*-butoxy, and *n*-pentoxy.

[0016] "Alkenyl" refers to a linear or branched hydrocarbyl group having from 2 to 10 carbon atoms and in some embodiments from 2 to 6 carbon atoms or 2 to 4 carbon atoms and having at least 1 site of vinyl unsaturation (>C=C<). For example, (C_x-C_y)alkenyl refers to alkenyl groups having from x to y carbon atoms and is meant to include for example, ethenyl, propenyl, 1,3-butadienyl, and so forth.

[0017] "Aryl" refers to an aromatic group of from 3 to 14 carbon atoms and no ring heteroatoms and having a single ring (e.g., phenyl) or multiple condensed (fused) rings (e.g., naphthyl or anthryl). For multiple ring systems, including fused,

bridged, and spiro ring systems having aromatic and non-aromatic rings that have no ring heteroatoms, the term "Aryl" applies when the point of attachment is at an aromatic carbon atom (e.g., 5,6,7,8 tetrahydronaphthalene-2-yl is an aryl group as its point of attachment is at the 2-position of the aromatic phenyl ring).

[0018] "Aryloxy" refers to the group -O-aryl, which includes, by way of example, phenoxy and naphthyloxy.

[0019] "Carboxyl" or "carboxy" refers to -COOH or salts thereof.

[0020] "Carboxyl ester" or "carboxy ester" refers to the groups -C(O)O-alkyl, C(O)O-alkenyl, C(O)O-aryl, C(O)O cycloalkyl, -C(O)O-heteroaryl, and -C(O)O-heterocyclic.

[0021] "Cycloalkyl" refers to a saturated or partially saturated cyclic group of from 3 to 14 carbon atoms and no ring heteroatoms and having a single ring or multiple rings including fused, bridged, and spiro ring systems. For multiple ring systems having aromatic and non-aromatic rings that have no ring heteroatoms, the term "cycloalkyl" applies when the point of attachment is at a non-aromatic carbon atom (e.g., 5,6,7,8-tetrahydronaphthalene-5-yl). The term "cycloalkyl" includes cycloalkenyl groups, such as adamantyl, cyclopropyl, cyclobutyl, cyclopentyl, cyclooctyl, and cyclohexenyl. The term "cycloalkenyl" is sometimes employed to refer to a partially saturated cycloalkyl ring having at least one site of >C=C< ring unsaturation.

[0022] "Cycloalkyloxy" refers to -O cycloalkyl.

[0023] "Halo" or "halogen" refers to fluoro, chloro, bromo, and iodo.

[0024] "Haloalkyl" refers to substitution of alkyl groups with 1 to 5 or in some embodiments 1 to 3 halo groups.

[0025] "Heteroaryl" refers to an aromatic group of from 1 to 14 carbon atoms and 1 to 6 heteroatoms selected from oxygen, nitrogen, and sulfur and includes single ring (e.g., imidazolyl) and multiple ring systems (e.g., benzimidazol-2-yl and benzimidazol-6-yl). For multiple ring systems, including fused, bridged, and spiro ring systems having aromatic and non-aromatic rings, the term "heteroaryl" applies if there is at least one ring heteroatom and the point of attachment is at an atom of an aromatic ring (e.g., 1,2,3,4-tetrahydroquinolin-6-yl and 5,6,7,8-tetrahydroquinolin-3-yl). In some embodiments, the nitrogen and/or the sulfur ring atom(s) of the heteroaryl group are optionally oxidized to provide for the N oxide

(N→O), sulfinyl, or sulfonyl moieties. Examples of heteroaryl groups include, but are not limited to, pyridyl, furanyl, thienyl, thiazolyl, isothiazolyl, triazolyl, imidazolyl, imidazoliny, isoxazolyl, pyrrolyl, pyrazolyl, pyridazinyl, pyrimidinyl, purinyl, phthalazyl, naphthylpyridyl, benzofuranyl, tetrahydrobenzofuranyl, isobenzofuranyl, benzothiazolyl, benzoisothiazolyl, benzotriazolyl, indolyl, isoindolyl, indoliziny, dihydroindolyl, indazolyl, indoliny, benzoxazolyl, quinolyl, isoquinolyl, quinolizyl, quianazolyl, quinoxalyl, tetrahydroquinoliny, isoquinolyl, quinazolinonyl, benzimidazolyl, benzisoxazolyl, benzothienyl, benzopyridazinyl, pteridiny, carbazolyl, carboliny, phenanthridiny, acridiny, phenanthroliny, phenaziny, phenoxaziny, phenothiaziny, and phthalimidyl.

[0026] "Heteroaryloxy" refers to –O-heteroaryl.

[0027] "Heterocyclic" or "heterocycle" or "heterocycloalkyl" or "heterocyclyl" refers to a saturated or partially saturated cyclic group having from 1 to 14 carbon atoms and from 1 to 6 heteroatoms selected from nitrogen, sulfur, or oxygen and includes single ring and multiple ring systems including fused, bridged, and spiro ring systems. For multiple ring systems having aromatic and/or non-aromatic rings, the terms "heterocyclic", "heterocycle", "heterocycloalkyl", or "heterocyclyl" apply when there is at least one ring heteroatom and the point of attachment is at an atom of a non-aromatic ring (e.g., decahydroquinolin-6-yl). In some embodiments, the nitrogen and/or sulfur atom(s) of the heterocyclic group are optionally oxidized to provide for the N oxide, sulfinyl, sulfonyl moieties. Examples of heterocyclyl groups include, but are not limited to, azetidiny, tetrahydropyrany, piperidiny, N-methylpiperidin-3-yl, piperaziny, N-methylpyrrolidin-3-yl, 3-pyrrolidinyl, 2-pyrrolidon-1-yl, morpholiny, thiomorpholiny, imidazolidiny, and pyrrolidinyl.

[0028] "Heterocyclyloxy" refers to the group –O-heterocyclyl.

[0029] "Acyl" refers to the groups H-C(O)-, alkyl-C(O)-, alkenyl-C(O)-, cycloalkyl-C(O)-, aryl-C(O)-, heteroaryl-C(O)-, and heterocyclic-C(O)-. Acyl includes the "acetyl" group CH₃C(O)-.

[0030] "Acyloxy" refers to the groups alkyl-C(O)O-, alkenyl-C(O)O-, aryl-C(O)O-, cycloalkyl-C(O)O-, heteroaryl-C(O)O-, and heterocyclic-C(O)O-. Acyloxy includes the "acetyloxy" group CH₃C(O)O-.

[0031] “Acylamino” refers to the groups -NHC(O)alkyl, -NHC(O)alkenyl, -NHC(O)cycloalkyl, -NHC(O)aryl, -NHC(O)heteroaryl, and -NHC(O)heterocyclic. Acylamino includes the “acetylamino” group -NHC(O)CH₃.

[0032] It should be understood that the aforementioned definitions encompass unsubstituted groups, as well as groups substituted with one or more other functional groups as is known in the art. For example, an aryl, heteroaryl, cycloalkyl, or heterocyclyl group may be substituted with from 1 to 8, in some embodiments from 1 to 5, in some embodiments from 1 to 3, and in some embodiments, from 1 to 2 substituents selected from alkyl, alkenyl, alkynyl, alkoxy, acyl, acylamino, acyloxy, amino, quaternary amino, amide, imino, amidino, aminocarbonylamino, amidinocarbonylamino, aminothiocarbonyl, aminocarbonylamino, aminothiocarbonylamino, aminocarbonyloxy, aminosulfonyl, aminosulfonyloxy, aminosulfonylamino, aryl, aryloxy, arylthio, azido, carboxyl, carboxyl ester, (carboxyl ester)amino, (carboxyl ester)oxy, cyano, cycloalkyl, cycloalkyloxy, cycloalkylthio, guanidino, halo, haloalkyl, haloalkoxy, hydroxy, hydroxyamino, alkoxyamino, hydrazino, heteroaryl, heteroaryloxy, heteroarylthio, heterocyclyl, heterocyclyloxy, heterocyclylthio, nitro, oxo, thione, phosphate, phosphonate, phosphinate, phosphoramidate, phosphorodiamidate, phosphoramidate monoester, cyclic phosphoramidate, cyclic phosphorodiamidate, phosphoramidate diester, sulfate, sulfonate, sulfonyl, substituted sulfonyl, sulfonyloxy, thioacyl, thiocyanate, thiol, alkylthio, etc., as well as combinations of such substituents.

[0033] It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary embodiments only, and is not intended as limiting the broader aspects of the present invention.

[0034] Generally speaking, the present invention is directed to a liquid crystalline polymer composition having a relatively high comparative tracking index (“CTI”). More particularly, the composition has a CTI that is about 225 volts or more, in some embodiments about 250 volts or more, in some embodiments about 275 volts or more, in some embodiments about 300 volts or more, and in some embodiments, from about 325 volts to about 600 volts. The present inventors have discovered that such high CTI values can be achieved through the use of inorganic particles in combination with a functional aromatic

compound. While not fully understood, it is believed that the functional compound can react with the liquid crystalline polymer and create smaller degraded polymer chains. In combination with the inorganic particles, these smaller chains can potentially form insulated regions at the surface of the polymer that hinder the formation of conductive carbonaceous deposits during the tracking process, which could otherwise lead to failure during testing.

[0035] Conventionally, it was believed that polymer compositions having a high voltage capacity would not also possess sufficiently good thermal and mechanical properties to enable their use in certain types of applications. Contrary to conventional thought, however, the polymer composition of the present invention has been found to possess excellent properties. For example, the melt viscosity of the polymer composition may be low enough so that it can readily flow into the cavity of a mold having small dimensions. In one particular embodiment, the polymer composition may have a melt viscosity of from about 0.1 to about 80 Pa-s, in some embodiments from about 0.5 to about 50 Pa-s, and in some embodiments, from about 1 to about 30 Pa-s, determined at a shear rate of 1000 seconds⁻¹. Melt viscosity may be determined in accordance with ISO Test No. 11443 at a temperature that is 15°C higher than the melting temperature of the composition (e.g., 350°C).

[0036] Even at such low viscosities, the composition may still possess a relatively high impact strength, which is useful when forming small parts for high voltage electronic devices. The composition may, for instance, possess a Charpy notched impact strength greater than about 4 kJ/m², in some embodiments from about 5 to about 40 kJ/m², and in some embodiments, from about 6 to about 30 kJ/m², measured at 23°C according to ISO Test No. 179-1) (technically equivalent to ASTM D256, Method B). The tensile and flexural mechanical properties of the composition may also be good. For example, the polymer composition may exhibit a tensile strength of from about 20 to about 500 MPa, in some embodiments from about 50 to about 400 MPa, and in some embodiments, from about 100 to about 350 MPa; a tensile break strain of about 0.5% or more, in some embodiments from about 0.6% to about 20%, and in some embodiments, from about 0.8% to about 3.5%; and/or a tensile modulus of from about 5,000 MPa to about 30,000 MPa, in some embodiments from about 8,000 MPa to about 20,000 MPa, and in some

embodiments, from about 10,000 MPa to about 15,000 MPa. The tensile properties may be determined in accordance with ISO Test No. 527 (technically equivalent to ASTM D638) at 23°C. The polymer composition may also exhibit a flexural strength of from about 20 to about 500 MPa, in some embodiments from about 50 to about 400 MPa, and in some embodiments, from about 100 to about 350 MPa; a flexural break strain of about 0.5% or more, in some embodiments from about 0.6% to about 20%, and in some embodiments, from about 0.8% to about 3.5%; and/or a flexural modulus of from about 5,000 MPa to about 30,000 MPa, in some embodiments from about 8,000 MPa to about 20,000 MPa, and in some embodiments, from about 10,000 MPa to about 15,000 MPa. The flexural properties may be determined in accordance with ISO Test No. 178 (technically equivalent to ASTM D790) at 23°C.

[0037] The polymer composition may also possess improved flame resistance performance, even in the absence of conventional flame retardants. The flame resistance of the composition may, for instance, be determined in accordance the procedure of Underwriter's Laboratory Bulletin 94 entitled "Tests for Flammability of Plastic Materials, UL94." Several ratings can be applied based on the time to extinguish (total flame time) and ability to resist dripping as described in more detail below. According to this procedure, for example, a molded part formed from the composition of the present invention may achieve a V0 rating, which means that the part has a total flame time of 50 seconds or less and a total number of drips of burning particles that ignite cotton of 0, determined at a given part thickness (e.g., 0.25 or 0.8 mm). For example, when exposed to an open flame, a molded part formed from the composition of the present invention may exhibit a total flame time of about 50 seconds or less, in some embodiments about 45 seconds or less, and in some embodiments, from about 1 to about 40 seconds. Furthermore, the total number of drips of burning particles produced during the UL94 test may be 3 or less, in some embodiments 2 or less, and in some embodiments, 1 or less (e.g., 0). Such testing may be performed after conditioning for 48 hours at 23°C and 50% relative humidity.

[0038] The relative concentration of functional aromatic compounds and inorganic particles in the composition may be selected in the present invention to achieve the desired properties. Surprisingly, the present inventors have

discovered that relatively low concentrations can significantly improve the CTI and melt viscosity. In this regard, functional aromatic compounds typically constitute from about 0.001 wt.% to about 5 wt.%, in some embodiments from about 0.01 wt.% to about 1 wt.%, and in some embodiments, from about 0.05 wt.% to about 0.5 wt.% of the polymer composition. The amount of inorganic particles may likewise range from about 1 wt.% to about 60 wt.%, in some embodiments from about 5 wt.% to about 55 wt.%, in some embodiments, from about 15 wt.% to about 50 wt.%. While the concentration of the liquid crystalline polymers may generally vary based on the presence of other optional components, they are typically present in an amount of from about 20 wt.% to about 90 wt.%, in some embodiments from about 30 wt.% to about 80 wt.%, and in some embodiments, from about 40 wt.% to about 70 wt.%.

[0039] Various embodiments of the present invention will now be described in more detail.

I. Liquid Crystalline Polymer

[0040] The thermotropic liquid crystalline polymer generally has a high degree of crystallinity that enables it to effectively fill the small spaces of a mold. Suitable thermotropic liquid crystalline polymers may include aromatic polyesters, aromatic poly(esteramides), aromatic poly(estercarbonates), aromatic polyamides, etc., and may likewise contain repeating units formed from one or more aromatic hydroxycarboxylic acids, aromatic dicarboxylic acids, aromatic diols, aromatic aminocarboxylic acids, aromatic amines, aromatic diamines, etc., as well as combinations thereof.

[0041] Aromatic polyesters, for instance, may be obtained by polymerizing (1) two or more aromatic hydroxycarboxylic acids; (2) at least one aromatic hydroxycarboxylic acid, at least one aromatic dicarboxylic acid, and at least one aromatic diol; and/or (3) at least one aromatic dicarboxylic acid and at least one aromatic diol. Examples of suitable aromatic hydroxycarboxylic acids include, 4-hydroxybenzoic acid; 4-hydroxy-4'-biphenylcarboxylic acid; 2-hydroxy-6-naphthoic acid; 2-hydroxy-5-naphthoic acid; 3-hydroxy-2-naphthoic acid; 2-hydroxy-3-naphthoic acid; 4'-hydroxyphenyl-4-benzoic acid; 3'-hydroxyphenyl-4-benzoic acid; 4'-hydroxyphenyl-3-benzoic acid, etc., as well as alkyl, alkoxy, aryl and halogen substituents thereof. Examples of suitable aromatic dicarboxylic acids include

terephthalic acid; isophthalic acid; 2,6-naphthalenedicarboxylic acid; diphenyl ether-4,4'-dicarboxylic acid; 1,6-naphthalenedicarboxylic acid; 2,7-naphthalenedicarboxylic acid; 4,4'-dicarboxybiphenyl; bis(4-carboxyphenyl)ether; bis(4-carboxyphenyl)butane; bis(4-carboxyphenyl)ethane; bis(3-carboxyphenyl)ether; bis(3-carboxyphenyl)ethane, etc., as well as alkyl, alkoxy, aryl and halogen substituents thereof. Examples of suitable aromatic diols include hydroquinone; resorcinol; 2,6-dihydroxynaphthalene; 2,7-dihydroxynaphthalene; 1,6-dihydroxynaphthalene; 4,4'-dihydroxybiphenyl; 3,3'-dihydroxybiphenyl; 3,4'-dihydroxybiphenyl; 4,4'-dihydroxybiphenyl ether; bis(4-hydroxyphenyl)ethane, etc., as well as alkyl, alkoxy, aryl and halogen substituents thereof. The synthesis and structure of these and other aromatic polyesters may be described in more detail in U.S. Patent Nos. 4,161,470; 4,473,682; 4,522,974; 4,375,530; 4,318,841; 4,256,624; 4,219,461; 4,083,829; 4,184,996; 4,279,803; 4,337,190; 4,355,134; 4,429,105; 4,393,191; 4,421,908; 4,434,262; and 5,541,240.

[0042] Liquid crystalline polyesteramides may likewise be obtained by polymerizing (1) at least one aromatic hydroxycarboxylic acid and at least one aromatic aminocarboxylic acid; (2) at least one aromatic hydroxycarboxylic acid, at least one aromatic dicarboxylic acid, and at least one aromatic amine and/or diamine optionally having phenolic hydroxy groups; and (3) at least one aromatic dicarboxylic acid and at least one aromatic amine and/or diamine optionally having phenolic hydroxy groups. Suitable aromatic amines and diamines may include, for instance, 3-aminophenol; 4-aminophenol; 1,4-phenylenediamine; 1,3-phenylenediamine, etc., as well as alkyl, alkoxy, aryl and halogen substituents thereof. In one particular embodiment, the aromatic polyesteramide contains monomer units derived from 2,6-hydroxynaphthoic acid, terephthalic acid, and 4-aminophenol. In another embodiment, the aromatic polyesteramide contains monomer units derived from 2,6-hydroxynaphthoic acid, and 4-hydroxybenzoic acid, and 4-aminophenol, as well as other optional monomers (e.g., 4,4'-dihydroxybiphenyl and/or terephthalic acid). The synthesis and structure of these and other aromatic poly(esteramides) may be described in more detail in U.S. Patent Nos. 4,339,375; 4,355,132; 4,351,917; 4,330,457; 4,351,918; and 5,204,443.

[0043] Although not necessarily required, the liquid crystalline polymer may be a "low naphthenic" polymer to the extent that it contains a minimal content of repeating units derived from naphthenic hydroxycarboxylic acids and naphthenic dicarboxylic acids, such as naphthalene-2,6-dicarboxylic acid ("NDA"), 6-hydroxy-2-naphthoic acid ("HNA"), or combinations thereof. That is, the total amount of repeating units derived from naphthenic hydroxycarboxylic and/or dicarboxylic acids (e.g., NDA, HNA, or a combination of HNA and NDA) is typically no more than 15 mol.%, in some embodiments no more than about 13 mol.%, in some embodiments no more than about 10 mol.%, in some embodiments no more than about 8 mol.%, and in some embodiments, from 0 mol.% to about 5 mol.% of the polymer (e.g., 0 mol.%). Despite the absence of a high level of conventional naphthenic acids, it is believed that the resulting "low naphthenic" polymers are still capable of exhibiting good thermal and mechanical properties, as described above. In one particular embodiment, for example, a "low naphthenic" aromatic polyester may be formed that contains monomer repeat units derived from 4-hydroxybenzoic acid ("HBA"), terephthalic acid ("TA") and/or isophthalic acid ("IA"); as well as various other optional constituents. The monomer units derived from 4-hydroxybenzoic acid ("HBA") may constitute from about 40 mol.% to about 95 mol.%, in some embodiments from about 45 mol.% to about 90 mol.%, and in some embodiments, from about 50 mol.% to about 80 mol.% of the polymer, while the monomer units derived from terephthalic acid ("TA") and/or isophthalic acid ("IA") may each constitute from about 1 mol.% to about 30 mol.%, in some embodiments from about 2 mol.% to about 25 mol.%, and in some embodiments, from about 3 mol.% to about 20 mol.% of the polymer. Other possible monomer repeat units include aromatic diols, such as 4,4'-biphenol ("BP"), hydroquinone ("HQ"), etc. and aromatic amides, such as acetaminophen ("APAP"). In certain embodiments, for example, BP, HQ, and/or APAP may each constitute from about 1 mol.% to about 30 mol.%, in some embodiments from about 2 mol.% to about 25 mol.%, and in some embodiments, from about 3 mol.% to about 20 mol.% when employed. If desired, the polymer may also contain a small amount of 6-hydroxy-2-naphthoic acid ("HNA") within the ranges noted above.

[0044] The liquid crystalline polymers may be prepared by introducing the appropriate monomer(s) (e.g., aromatic hydroxycarboxylic acid, aromatic

dicarboxylic acid, aromatic diol, aromatic amine, aromatic diamine, etc.) into a reactor vessel to initiate a polycondensation reaction. The particular conditions and steps employed in such reactions are well known, and may be described in more detail in U.S. Patent No. 4,161,470 to Calundann; U.S. Patent No. 5,616,680 to Linstid, III, et al.; U.S. Patent No. 6,114,492 to Linstid, III, et al.; U.S. Patent No. 6,514,611 to Shepherd, et al.; and WO 2004/058851 to Waggoner. The vessel employed for the reaction is not especially limited, although it is typically desired to employ one that is commonly used in reactions of high viscosity fluids.

Examples of such a reaction vessel may include a stirring tank-type apparatus that has an agitator with a variably-shaped stirring blade, such as an anchor type, multistage type, spiral-ribbon type, screw shaft type, etc., or a modified shape thereof. Further examples of such a reaction vessel may include a mixing apparatus commonly used in resin kneading, such as a kneader, a roll mill, a Banbury mixer, etc.

[0045] If desired, the reaction may proceed through the acetylation of the monomers as referenced above and known the art. This may be accomplished by adding an acetylating agent (e.g., acetic anhydride) to the monomers. Acetylation is generally initiated at temperatures of about 90°C. During the initial stage of the acetylation, reflux may be employed to maintain vapor phase temperature below the point at which acetic acid byproduct and anhydride begin to distill.

Temperatures during acetylation typically range from between 90°C to 150°C, and in some embodiments, from about 110°C to about 150°C. If reflux is used, the vapor phase temperature typically exceeds the boiling point of acetic acid, but remains low enough to retain residual acetic anhydride. For example, acetic anhydride vaporizes at temperatures of about 140°C. Thus, providing the reactor with a vapor phase reflux at a temperature of from about 110°C to about 130°C is particularly desirable. To ensure substantially complete reaction, an excess amount of acetic anhydride may be employed. The amount of excess anhydride will vary depending upon the particular acetylation conditions employed, including the presence or absence of reflux. The use of an excess of from about 1 to about 10 mole percent of acetic anhydride, based on the total moles of reactant hydroxyl groups present is not uncommon.

[0046] Acetylation may occur in a separate reactor vessel, or it may occur *in situ* within the polymerization reactor vessel. When separate reactor vessels are employed, one or more of the monomers may be introduced to the acetylation reactor and subsequently transferred to the polymerization reactor. Likewise, one or more of the monomers may also be directly introduced to the reactor vessel without undergoing pre-acetylation.

[0047] In addition to the monomers and optional acetylating agents, other components may also be included within the reaction mixture to help facilitate polymerization. For instance, a catalyst may be optionally employed, such as metal salt catalysts (e.g., magnesium acetate, tin(II) acetate, tetrabutyl titanate, lead acetate, sodium acetate, potassium acetate, etc.) and organic compound catalysts (e.g., N-methylimidazole). Such catalysts are typically used in amounts of from about 50 to about 500 parts per million based on the total weight of the recurring unit precursors. When separate reactors are employed, it is typically desired to apply the catalyst to the acetylation reactor rather than the polymerization reactor, although this is by no means a requirement.

[0048] The reaction mixture is generally heated to an elevated temperature within the polymerization reactor vessel to initiate melt polycondensation of the reactants. Polycondensation may occur, for instance, within a temperature range of from about 210°C to about 400°C, and in some embodiments, from about 250°C to about 350°C. For instance, one suitable technique for forming an aromatic polyester may include charging precursor monomers (e.g., 4-hydroxybenzoic acid and 2,6-hydroxynaphthoic acid) and acetic anhydride into the reactor, heating the mixture to a temperature of from about 90°C to about 150°C to acetylate a hydroxyl group of the monomers (e.g., forming acetoxy), and then increasing the temperature to a temperature of from about 210°C to about 400°C to carry out melt polycondensation. As the final polymerization temperatures are approached, volatile byproducts of the reaction (e.g., acetic acid) may also be removed so that the desired molecular weight may be readily achieved. The reaction mixture is generally subjected to agitation during polymerization to ensure good heat and mass transfer, and in turn, good material homogeneity. The rotational velocity of the agitator may vary during the course of the reaction, but typically ranges from about 10 to about 100 revolutions per minute ("rpm"),

and in some embodiments, from about 20 to about 80 rpm. To build molecular weight in the melt, the polymerization reaction may also be conducted under vacuum, the application of which facilitates the removal of volatiles formed during the final stages of polycondensation. The vacuum may be created by the application of a suctional pressure, such as within the range of from about 5 to about 30 pounds per square inch ("psi"), and in some embodiments, from about 10 to about 20 psi.

[0049] Following melt polymerization, the molten polymer may be discharged from the reactor, typically through an extrusion orifice fitted with a die of desired configuration, cooled, and collected. Commonly, the melt is discharged through a perforated die to form strands that are taken up in a water bath, pelletized and dried. The resin may also be in the form of a strand, granule, or powder. While unnecessary, it should also be understood that a subsequent solid phase polymerization may be conducted to further increase molecular weight. When carrying out solid-phase polymerization on a polymer obtained by melt polymerization, it is typically desired to select a method in which the polymer obtained by melt polymerization is solidified and then pulverized to form a powdery or flake-like polymer, followed by performing solid polymerization method, such as a heat treatment in a temperature range of 200°C to 350°C under an inert atmosphere (e.g., nitrogen).

[0050] Regardless of the particular method employed, the resulting liquid crystalline polymer typically may have a high number average molecular weight (M_n) of about 2,000 grams per mole or more, in some embodiments from about 4,000 grams per mole or more, and in some embodiments, from about 5,000 to about 30,000 grams per mole. Of course, it is also possible to form polymers having a lower molecular weight, such as less than about 2,000 grams per mole, using the method of the present invention. The intrinsic viscosity of the polymer, which is generally proportional to molecular weight, may also be relatively high. For example, the intrinsic viscosity may be about about 4 deciliters per gram ("dL/g") or more, in some embodiments about 5 dL/g or more, in some embodiments from about 6 to about 20 dL/g, and in some embodiments from about 7 to about 15 dL/g. Intrinsic viscosity may be determined in accordance

with ISO-1628-5 using a 50/50 (v/v) mixture of pentafluorophenol and hexafluoroisopropanol.

II. Inorganic Particles

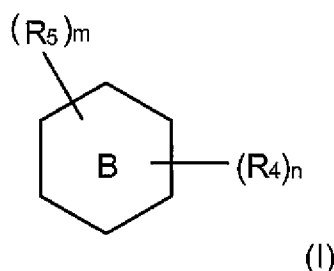
[0051] Any of a variety of inorganic particles may generally be employed in the composition of the present invention, such as diatomaceous earth and wollastonite; metal oxides (e.g., iron oxides, titanium oxides, barium oxides, zinc oxides and alumina); metal carbonates (e.g., calcium carbonate and magnesium carbonate); metal sulfates (e.g., calcium sulfate and barium sulfate); phosphates of aluminum, calcium, magnesium, zinc, cerium and mixed metals; titanates of magnesium, calcium, aluminum and mixed metals; fluorides of magnesium and calcium; silicates of zinc, zirconium, calcium, barium, magnesium, mixed alkaline earths and naturally occurring silicate minerals; aluminosilicates of alkali and alkaline earths, and naturally occurring aluminosilicates; oxalates of calcium, zinc, magnesium, aluminum and mixed metals; aluminates of zinc, calcium, magnesium, and mixed alkaline earth silicon carbide; silicon nitride; and boron nitride. Particularly suitable particles include those formed from titanium dioxide. The surface of such particles may be untreated, or may be coated with an oxide of a metal (e.g., aluminum, silicon or zirconium) or organic acid (e.g., stearic acid or lauric acid). Suitable crystal forms of titanium dioxide may include anatase and rutile. The titanium dioxide particles may possess any discrete form such as particles, flakes, etc.

[0052] The size of the inorganic particles may generally vary, but is typically about 5 micrometers or less, in some embodiments about 2 micrometers or less, and in some embodiments, from about 10 to about 500 nanometers. Aggregates or agglomerates of inorganic particles may also be employed in which the primary particle size and/or agglomerate size is within the ranges noted above.

II. Functional Aromatic Compound

[0053] As indicated above, the polymer composition of the present invention also contains functional aromatic compound. Such compounds generally contain one or more carboxyl and/or hydroxyl functional groups that can react with the polymer chain to shorten its length as described above. In certain cases, the compound may also be able to combine smaller chains of the

polymer together after they have been cut to help maintain the mechanical properties of the composition even after its melt viscosity has been reduced. The functional compound typically has the general structure provided below in Formula (I):



or a metal salt thereof, wherein,

ring B is a 6-membered aromatic ring wherein 1 to 3 ring carbon atoms are optionally replaced by nitrogen or oxygen, wherein each nitrogen is optionally oxidized, and wherein ring B may be optionally fused or linked to a 5- or 6-membered aryl, heteroaryl, cycloalkyl, or heterocyclyl;

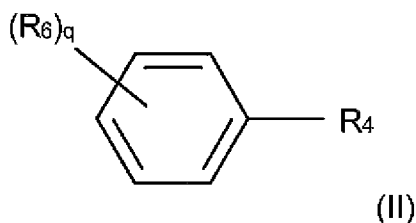
R_4 is OH or COOH;

R_5 is acyl, acyloxy (e.g., acetyloxy), acylamino (e.g., acetylamino), alkoxy, alkenyl, alkyl, amino, aryl, aryloxy, carboxyl, carboxyl ester, cycloalkyl, cycloalkyloxy, hydroxyl, halo, haloalkyl, heteroaryl, heteroaryloxy, heterocyclyl, or heterocycloxy;

m is from 0 to 4, in some embodiments from 0 to 2, and in some embodiments, from 0 to 1; and

n is from 1 to 3, and in some embodiments, from 1 to 2. When the compound is in the form of a metal salt, suitable metal counterions may include transition metal counterions (e.g., copper, iron, etc.), alkali metal counterions (e.g., potassium, sodium, etc.), alkaline earth metal counterions (e.g., calcium, magnesium, etc.), and/or main group metal counterions (e.g., aluminum).

[0054] In one embodiment, for example, B is phenyl in Formula (I) such that the resulting phenolic compounds have the following general formula (II):



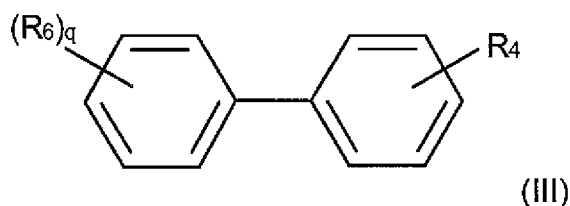
or a metal salt thereof, wherein,

R_4 is OH or COOH;

R_6 is acyl, acyloxy, acylamino, alkoxy, alkenyl, alkyl, amino, carboxyl, carboxyl ester, hydroxyl, halo, or haloalkyl; and

q is from 0 to 4, in some embodiments from 0 to 2, and in some embodiments, from 0 to 1. Particular examples of such phenolic compounds include, for instance, benzoic acid (q is 0); 4-hydroxybenzoic acid (R_4 is COOH, R_6 is OH, and q is 1); phthalic acid (R_4 is COOH, R_6 is COOH, and q is 1); isophthalic acid (R_4 is COOH, R_6 is COOH, and q is 1); terephthalic acid (R_4 is COOH, R_6 is COOH, and q is 1); 2-methylterephthalic acid (R_4 is COOH, R_6 is COOH, and CH_3 and q is 2); phenol (R_4 is OH and q is 0); sodium phenoxide (R_4 is OH and q is 0); hydroquinone (R_4 is OH, R_6 is OH, and q is 1); resorcinol (R_4 is OH, R_6 is OH, and q is 1); 4-hydroxybenzoic acid (R_4 is OH, R_6 is C(O)OH, and q is 1), etc., as well as combinations thereof.

[0055] In another embodiment, B is phenyl and R_5 is phenyl in Formula (I) above such that the diphenolic compounds have the following general formula (III):



or a metal salt thereof, wherein,

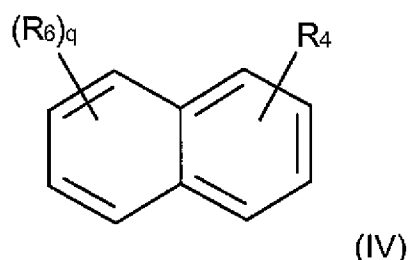
R_4 is COOH or OH;

R_6 is acyl, acyloxy, acylamino, alkoxy, alkenyl, alkyl, amino, aryl, aryloxy, carboxyl, carboxyl ester, cycloalkyl, cycloalkyloxy, hydroxyl, halo, haloalkyl, heteroaryl, heteroaryloxy, heterocyclyl, or heterocycloxy; and

q is from 0 to 4, in some embodiments from 0 to 2, and in some embodiments, from 0 to 1. Particular examples of such diphenolic compounds include, for instance, 4-hydroxy-4'-biphenylcarboxylic acid (R_4 is COOH, R_6 is OH, and q is 1); 4'-hydroxyphenyl-4-benzoic acid (R_4 is COOH, R_6 is OH, and q is 1); 3'-hydroxyphenyl-4-benzoic acid (R_4 is COOH, R_6 is OH, and q is 1); 4'-hydroxyphenyl-3-benzoic acid (R_4 is COOH, R_6 is OH, and q is 1); 4,4'-bibenzoic acid (R_4 is COOH, R_6 is COOH, and q is 1); (R_4 is OH, R_6 is OH, and q is 1); 3,3'-

biphenol (R_4 is OH, R_6 is OH, and q is 1); 3,4'-biphenol (R_4 is OH, R_6 is OH, and q is 1); 4-phenylphenol (R_4 is OH and q is 0); bis(4-hydroxyphenyl)ethane (R_4 is OH, R_6 is $C_2(OH)_2$ phenol, and q is 1); tris(4-hydroxyphenyl)ethane (R_4 is OH, R_6 is $C(CH_3)$ biphenol, and q is 1); 4-hydroxy-4'-biphenylcarboxylic acid (R_4 is OH, R_6 is COOH, and q is 1); 4'-hydroxyphenyl-4-benzoic acid (R_4 is OH, R_6 is COOH, and q is 1); 3'-hydroxyphenyl-4-benzoic acid (R_4 is OH, R_6 is COOH, and q is 1); 4'-hydroxyphenyl-3-benzoic acid (R_4 is OH, R_6 is COOH, and q is 1); etc., as well as combinations thereof.

[0056] In yet another embodiment, B is naphthenyl in Formula (I) above such that the resulting naphthenic compounds have the following general formula (IV):



or a metal salt thereof, wherein,

R_4 is OH or COOH;

R_6 is acyl, acyloxy, acylamino, alkoxy, alkenyl, alkyl, amino, aryl, aryloxy, carboxyl, carboxyl ester, cycloalkyl, cycloalkyloxy, hydroxyl, halo, haloalkyl, heteroaryl, heteroaryloxy, heterocyclyl, or heterocycloxy; and

q is from 0 to 4, in some embodiments from 0 to 2, and in some embodiments, from 0 to 1. Particular examples of such naphthenic compounds include, for instance, 1-naphthoic acid (R_4 is COOH and q is 0); 2-naphthoic acid (R_4 is COOH and q is 0); 2-hydroxy-6-naphthoic acid (R_4 is COOH, R_6 is OH, and q is 1); 2-hydroxy-5-naphthoic acid (R_4 is COOH, R_6 is OH, and q is 1); 3-hydroxy-2-naphthoic acid (R_4 is COOH, R_6 is OH, and q is 1); 2-hydroxy-3-naphthoic acid (R_4 is COOH, R_6 is OH, and q is 1); 2,6-naphthalenedicarboxylic acid (R_4 is COOH, R_6 is COOH, and q is 1); 2,3-naphthalenedicarboxylic acid (R_4 is COOH, R_6 is COOH, and q is 1); 2-hydroxy-naphthelene (R_4 is OH and q is 0); 2-hydroxy-6-naphthoic acid (R_4 is OH, R_6 is COOH, and q is 1); 2-hydroxy-5-naphthoic acid (R_4 is OH, R_6 is COOH, and q is 1); 3-hydroxy-2-naphthoic acid (R_4 is OH, R_6 is COOH, and q is 1); 2-hydroxy-3-naphthoic acid (R_4 is OH, R_6 is COOH, and q is 1);

1); 2,6-dihydroxynaphthalene (R_4 is OH, R_6 is OH, and q is 1); 2,7-dihydroxynaphthalene (R_4 is OH, R_6 is OH, and q is 1); 1,6-dihydroxynaphthalene (R_4 is OH, R_6 is OH, and q is 1), etc., as well as combinations thereof.

[0057] In certain embodiments of the present invention, for example, the polymer composition may contain an aromatic diol, such as hydroquinone, resorcinol, 4,4'-biphenol, etc., as well as combinations thereof. When employed, such aromatic diols may constitute from about 0.01 wt.% to about 1 wt.%, and in some embodiments, from about 0.05 wt.% to about 0.4 wt.% of the polymer composition. An aromatic carboxylic acid may also be employed in certain embodiments, either alone or in conjunction with the aromatic diol. Aromatic carboxylic acids may constitute from about 0.001 wt.% to about 0.5 wt.%, and in some embodiments, from about 0.005 wt.% to about 0.1 wt.% of the polymer composition. In particular embodiments, a combination of an aromatic diol (R_4 and R_6 are OH in the formulae above) (e.g., 4,4'-biphenol) and an aromatic dicarboxylic acid (R_4 and R_6 are COOH in the formulae above) (e.g., 2,6-naphthalene dicarboxylic acid) is employed in the present invention to help achieve the desired CTI values.

III. Optional Components

A. Non-Aromatic Functional Compounds

[0058] In addition to those noted above, non-aromatic functional compounds may also be employed in the present invention. Such compounds may serve a variety of purposes, such as assisting in the improvement of the CTI values, reducing melt viscosity, etc. One such non-aromatic functional compound is water. If desired, water can be added in a form that under process conditions generates water. For example, the water can be added as a hydrate that under the process conditions (e.g., high temperature) effectively "loses" water. Such hydrates include alumina trihydrate, copper sulfate pentahydrate, barium chloride dihydrate, calcium sulfate dehydrate, etc., as well as combinations thereof. When employed, the hydrates may constitute from about 0.02 wt.% to about 2 wt.%, and in some embodiments, from about 0.05 wt.% to about 1 wt.% of the polymer composition. In one particular embodiment, a mixture of an aromatic diol, hydrate, and aromatic dicarboxylic acid are employed in the composition. In such embodiments, the weight ratio of hydrates to

aromatic diols is typically from about 0.5 to about 8, in some embodiments from about 0.8 to about 5, and in some embodiments, from about 1 to about 5.

B. Fillers

[0059] Various fillers may also be incorporated in the polymer composition if desired. For example, fibers may be employed in the polymer composition to improve the mechanical properties. Such fibers generally have a high degree of tensile strength relative to their mass. For example, the ultimate tensile strength of the fibers (determined in accordance with ASTM D2101) is typically from about 1,000 to about 15,000 Megapascals ("MPa"), in some embodiments from about 2,000 MPa to about 10,000 MPa, and in some embodiments, from about 3,000 MPa to about 6,000 MPa. To help maintain an insulative property, which is often desirable for use in electronic components, the high strength fibers may be formed from materials that are also generally insulative in nature, such as glass, ceramics (e.g., alumina or silica), aramids (e.g., Kevlar® marketed by E. I. duPont de Nemours, Wilmington, Del.), polyolefins, polyesters, etc., as well as mixtures thereof. Glass fibers are particularly suitable, such as E-glass, A-glass, C-glass, D-glass, AR-glass, R-glass, S1-glass, S2-glass, etc., and mixtures thereof.

[0060] The volume average length of the fibers may be from about 50 to about 400 micrometers, in some embodiments from about 80 to about 250 micrometers, in some embodiments from about 100 to about 200 micrometers, and in some embodiments, from about 110 to about 180 micrometers. The fibers may also have a narrow length distribution. That is, at least about 70% by volume of the fibers, in some embodiments at least about 80% by volume of the fibers, and in some embodiments, at least about 90% by volume of the fibers have a length within the range of from about 50 to about 400 micrometers, in some embodiments from about 80 to about 250 micrometers, in some embodiments from about 100 to about 200 micrometers, and in some embodiments, from about 110 to about 180 micrometers. Such a weight average length and narrow length distribution can further help achieve a desirable combination of strength and flowability, which enables it to be uniquely suited for molded parts with a small dimensional tolerance.

[0061] In addition to possessing the length characteristics noted above, the fibers may also have a relatively high aspect ratio (average length divided by nominal diameter) to help improve the mechanical properties of the resulting polymer composition. For example, the fibers may have an aspect ratio of from about 2 to about 50, in some embodiments from about 4 to about 40, and in some embodiments, from about 5 to about 20 are particularly beneficial. The fibers may, for example, have a nominal diameter of about 10 to about 35 micrometers, and in some embodiments, from about 15 to about 30 micrometers.

[0062] The relative amount of the fibers in the polymer composition may also be selectively controlled to help achieve the desired mechanical properties without adversely impacting other properties of the composition, such as its flowability. For example, the fibers typically constitute from about 2 wt.% to about 40 wt.%, in some embodiments from about 5 wt.% to about 35 wt.%, and in some embodiments, from about 6 wt.% to about 30 wt.% of the polymer composition. Although the fibers may be employed within the ranges noted above, one particularly beneficial and surprising aspect of the present invention is that small fiber contents may be employed while still achieving the desired mechanical properties. Without intending to be limited by theory, it is believed that the narrow length distribution of the fibers can help achieve excellent mechanical properties, thus allowing for the use of a smaller amount of fibers. For example, the fibers can be employed in small amounts such as from about 2 wt.% to about 20 wt.%, in some embodiments, from about 5 wt.% to about 16 wt.%, and in some embodiments, from about 6 wt.% to about 12 wt.%.

[0063] Mineral fillers may also be employed in the polymer composition to help achieve the desired properties and/or color. When employed, such mineral fillers typically constitute from about 5% by weight to about 40% by weight, in some embodiments from about 10% by weight to about 35% by weight, and in some embodiments, from about 10% by weight to about 30% by weight of the polymer composition. Clay minerals may be particularly suitable for use in the present invention. Examples of such clay minerals include, for instance, talc ($\text{Mg}_3\text{Si}_4\text{O}_{10}(\text{OH})_2$), halloysite ($\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$), kaolinite ($\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$), illite ($((\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})])$), montmorillonite ($(\text{Na}, \text{Ca})_{0.33}(\text{Al}, \text{Mg})_2\text{Si}_4\text{O}_{10}(\text{OH})_2 \cdot n\text{H}_2\text{O}$), vermiculite ($((\text{MgFe}, \text{Al})_3(\text{Al}, \text{Si})_4\text{O}_{10}(\text{OH})_2 \cdot$

4H₂O), palygorskite ((Mg,Al)₂Si₄O₁₀(OH)·4(H₂O)), pyrophyllite (Al₂Si₄O₁₀(OH)₂), etc., as well as combinations thereof. In lieu of, or in addition to, clay minerals, still other mineral fillers may also be employed. For example, other suitable silicate fillers may also be employed, such as calcium silicate, aluminum silicate, mica, diatomaceous earth, wollastonite, and so forth. Mica, for instance, may be a particularly suitable mineral for use in the present invention. There are several chemically distinct mica species with considerable variance in geologic occurrence, but all have essentially the same crystal structure. As used herein, the term "mica" is meant to generically include any of these species, such as muscovite (KAl₂(AlSi₃)O₁₀(OH)₂), biotite (K(Mg,Fe)₃(AlSi₃)O₁₀(OH)₂), phlogopite (KMg₃(AlSi₃)O₁₀(OH)₂), lepidolite (K(Li,Al)₂₋₃(AlSi₃)O₁₀(OH)₂), glauconite (K,Na)(Al,Mg,Fe)₂(Si,Al)₄O₁₀(OH)₂), etc., as well as combinations thereof.

C. Other Additives

[0064] Still other additives that can be included in the composition may include, for instance, antimicrobials, pigments, antioxidants, stabilizers, surfactants, waxes, solid solvents, flame retardants, anti-drip additives, and other materials added to enhance properties and processability.

[0065] Lubricants may also be employed in the polymer composition that are capable of withstanding the processing conditions of the liquid crystalline polymer without substantial decomposition. Examples of such lubricants include fatty acids esters, the salts thereof, esters, fatty acid amides, organic phosphate esters, and hydrocarbon waxes of the type commonly used as lubricants in the processing of engineering plastic materials, including mixtures thereof. Suitable fatty acids typically have a backbone carbon chain of from about 12 to about 60 carbon atoms, such as myristic acid, palmitic acid, stearic acid, arachic acid, montanic acid, octadecinic acid, parinric acid, and so forth. Suitable esters include fatty acid esters, fatty alcohol esters, wax esters, glycerol esters, glycol esters and complex esters. Fatty acid amides include fatty primary amides, fatty secondary amides, methylene and ethylene bisamides and alkanolamides such as, for example, palmitic acid amide, stearic acid amide, oleic acid amide, N,N'-ethylenebisstearamide and so forth. Also suitable are the metal salts of fatty acids such as calcium stearate, zinc stearate, magnesium stearate, and so forth; hydrocarbon waxes, including paraffin waxes, polyolefin and oxidized polyolefin

waxes, and microcrystalline waxes. Particularly suitable lubricants are acids, salts, or amides of stearic acid, such as pentaerythritol tetrastearate, calcium stearate, or N,N'-ethylenebisstearamide. When employed, the lubricant(s) typically constitute from about 0.05 wt.% to about 1.5 wt.%, and in some embodiments, from about 0.1 wt.% to about 0.5 wt.% (by weight) of the polymer composition.

IV. Formation of Composition

[0066] The liquid crystalline polymer, inorganic particles, functional aromatic compound, and other optional additives may be melt blended together within a temperature range of from about 200°C to about 450°C, in some embodiments, from about 220°C to about 400°C, and in some embodiments, from about 250°C to about 350°C to form the polymer composition. Any of a variety of melt blending techniques may generally be employed in the present invention. For example, the components (e.g., liquid crystalline polymer, inorganic particles, functional compound, etc.) may be supplied separately or in combination to an extruder that includes at least one screw rotatably mounted and received within a barrel (e.g., cylindrical barrel) and may define a feed section and a melting section located downstream from the feed section along the length of the screw.

[0067] The extruder may be a single screw or twin screw extruder. Referring to Fig. 3, for example, one embodiment of a single screw extruder 80 is shown that contains a housing or barrel 114 and a screw 120 rotatably driven on one end by a suitable drive 124 (typically including a motor and gearbox). If desired, a twin-screw extruder may be employed that contains two separate screws. The configuration of the screw is not particularly critical to the present invention and it may contain any number and/or orientation of threads and channels as is known in the art. As shown in Fig. 3, for example, the screw 120 contains a thread that forms a generally helical channel radially extending around a core of the screw 120. A hopper 40 is located adjacent to the drive 124 for supplying the liquid crystalline polymer and/or other materials (e.g., inorganic particles and/or functional compound) through an opening in the barrel 114 to the feed section 132. Opposite the drive 124 is the output end 144 of the extruder 80, where extruded plastic is output for further processing.

[0068] A feed section 132 and melt section 134 are defined along the length of the screw 120. The feed section 132 is the input portion of the barrel 114 where the liquid crystalline polymer, inorganic particles, and/or the functional compound are added. The melt section 134 is the phase change section in which the liquid crystalline polymer is changed from a solid to a liquid. While

there is no precisely defined delineation of these sections when the extruder is manufactured, it is well within the ordinary skill of those in this art to reliably identify the feed section 132 and the melt section 134 in which phase change from solid to liquid is occurring. Although not necessarily required, the extruder 80 may also have a mixing section 136 that is located adjacent to the output end of the barrel 114 and downstream from the melting section 134. If desired, one or more distributive and/or dispersive mixing elements may be employed within the mixing and/or melting sections of the extruder. Suitable distributive mixers for single screw extruders may include, for instance, Saxon, Dulmage, Cavity Transfer mixers, etc. Likewise, suitable dispersive mixers may include Blister ring, Leroy/Maddock, CRD mixers, etc. As is well known in the art, the mixing may be further improved by using pins in the barrel that create a folding and reorientation of the polymer melt, such as those used in Buss Kneader extruders, Cavity Transfer mixers, and Vortex Intermeshing Pin mixers.

[0069] When employed, fibers can also be added to the hopper 40 or at a location downstream therefrom. In one particular embodiment, fibers may be added a location downstream from the point at which the liquid crystalline polymer is supplied, but yet prior to the melting section. In Fig. 3, for instance, a hopper 42 is shown that is located within a zone of the feed section 132 of the extruder 80. The fibers supplied to the hopper 42 may be initially relatively long, such as having a volume average length of from about 1,000 to about 5,000 micrometers, in some embodiments from about 2,000 to about 4,500 micrometers, and in some embodiments, from about 3,000 to about 4,000 micrometers. Nevertheless, by supplying these long fibers at a location where the liquid crystalline polymer is still in a solid state, the polymer can act as an abrasive agent for reducing the size of the fibers to a volume average length and length distribution as indicated above.

[0070] If desired, the ratio of the length ("L") to diameter ("D") of the screw may be selected to achieve an optimum balance between throughput and fiber length reduction. The L/D value may, for instance, range from about 15 to about 50, in some embodiments from about 20 to about 45, and in some embodiments from about 25 to about 40. The length of the screw may, for instance, range from about 0.1 to about 5 meters, in some embodiments from about 0.4 to about 4

meters, and in some embodiments, from about 0.5 to about 2 meters. The diameter of the screw may likewise be from about 5 to about 150 millimeters, in some embodiments from about 10 to about 120 millimeters, and in some embodiments, from about 20 to about 80 millimeters. The L/D ratio of the screw after the point at which the fibers are supplied may also be controlled within a certain range. For example, the screw has a blending length (" L_B ") that is defined from the point at which the fibers are supplied to the extruder to the end of the screw, the blending length being less than the total length of the screw. As noted above, it may be desirable to add the fibers before the liquid crystalline polymer is melted, which means that the L_B/D ratio would be relatively high. However, too high of a L_B/D ratio could result in degradation of the polymer. Therefore, the L_B/D ratio of the screw after the point at which the fibers are supplied is typically from about 4 to about 20, in some embodiments from about 5 to about 15, and in some embodiments, from about 6 to about 10.

[0071] In addition to the length and diameter, other aspects of the extruder may also be selected to help achieve the desired fiber length. For example, the speed of the screw may be selected to achieve the desired residence time, shear rate, melt processing temperature, etc. Generally, an increase in frictional energy results from the shear exerted by the turning screw on the materials within the extruder and results in the fracturing of the fibers, if employed. The degree of fracturing may depend, at least in part, on the screw speed. For example, the screw speed may range from about 50 to about 800 revolutions per minute ("rpm"), in some embodiments from about 70 to about 150 rpm, and in some embodiments, from about 80 to about 120 rpm. The apparent shear rate during melt blending may also range from about 100 seconds^{-1} to about $10,000 \text{ seconds}^{-1}$, in some embodiments from about 500 seconds^{-1} to about $5000 \text{ seconds}^{-1}$, and in some embodiments, from about 800 seconds^{-1} to about $1200 \text{ seconds}^{-1}$. The apparent shear rate is equal to $4Q/\pi R^3$, where Q is the volumetric flow rate (" m^3/s ") of the polymer melt and R is the radius (" m ") of the capillary (e.g., extruder die) through which the melted polymer flows.

[0072] In the embodiments described above, the length of the fibers is reduced within the extruder. It should be understood, however, that this is by no means a requirement of the present invention. For example, the fibers may

simply be supplied to the extruder at the desired length. In such embodiments, the fibers may, for example, be supplied at the mixing and/or melting sections of the extruder, or even at the feed section in conjunction with the liquid crystalline polymer. In yet other embodiments, fibers may not be employed at all.

V. Molded Parts

[0073] Once formed, the polymer composition may be molded into any of a variety of different shaped parts using techniques as is known in the art. For example, the shaped parts may be molded using a one-component injection molding process in which dried and preheated plastic granules are injected into the mold. Regardless of the molding technique employed, it has been discovered that the polymer composition of the present invention, which possesses the unique combination of a high CTI, high flowability and good mechanical properties, is particularly well suited for electronic parts having a small dimensional tolerance. Such parts, for example, generally contain at least one micro-sized dimension (e.g., thickness, width, height, etc.), such as from about 500 micrometers or less, in some embodiments from about 50 to about 450 micrometers, and in some embodiments, from about 100 to about 400 micrometers.

[0074] One such part is a fine pitch electrical connector. More particularly, such electrical connectors are often employed to detachably mount a central processing unit ("CPU") to a printed circuit board. The connector may contain insertion passageways that are configured to receive contact pins. These passageways are defined by opposing walls, which may be formed from a thermoplastic resin. To help accomplish the desired electrical performance, the pitch of these pins is generally small to accommodate a large number of contact pins required within a given space. This, in turn, requires that the pitch of the pin insertion passageways and the width of opposing walls that partition those passageways are also small. For example, the walls may have a width of from about 500 micrometers or less, in some embodiments from about 50 to about 450 micrometers, and in some embodiments, from about 100 to about 400 micrometers. In the past, it has often been difficult to adequately fill a mold of such a thin width with a thermoplastic resin. Due to its unique properties,

however, the polymer composition of the present invention is particularly well suited to form the walls of a fine pitch connector.

[0075] One particularly suitable fine pitch electrical connector is shown in Fig. 1. An electrical connector 200 is shown that a board-side portion C2 that can be mounted onto the surface of a circuit board P. The connector 200 may also include a wiring material-side portion C1 structured to connect discrete wires 3 to the circuit board P by being coupled to the board-side connector C2. The board-side portion C2 may include a first housing 10 that has a fitting recess 10a into which the wiring material-side connector C1 is fitted and a configuration that is slim and long in the widthwise direction of the housing 10. The wiring material-side portion C1 may likewise include a second housing 20 that is slim and long in the widthwise direction of the housing 20. In the second housing 20, a plurality of terminal-receiving cavities 22 may be provided in parallel in the widthwise direction so as to create a two-tier array including upper and lower terminal-receiving cavities 22. A terminal 5, which is mounted to the distal end of a discrete wire 3, may be received within each of the terminal-receiving cavities 22. If desired, locking portions 28 (engaging portions) may also be provided on the housing 20 that correspond to a connection member (not shown) on the board-side connector C2.

[0076] As discussed above, the interior walls of the first housing 10 and/or second housing 20 may have a relatively small width dimension, and can be formed from the polymer composition of the present invention. The walls are, for example, shown in more detail in Fig. 2. As illustrated, insertion passageways or spaces 225 are defined between opposing walls 224 that can accommodate contact pins. The walls 224 have a width "w" that is within the ranges noted above. When the walls 224 are formed from a polymer composition containing fibers (e.g., element 400), such fibers may have a volume average length and narrow length distribution within a certain range to best match the width of the walls. For example, the ratio of the width of at least one of the walls to the volume average length of the fibers is from about 0.8 to about 3.2, in some embodiments from about 1.0 to about 3.0, and in some embodiments, from about 1.2 to about 2.9.

[0077] In addition to or in lieu of the walls, it should also be understood that any other portion of the housing may also be formed from the polymer composition of the present invention. For example, the connector may also include a shield that encloses the housing. Some or all of the shield may be formed from the polymer composition of the present invention. For example, the housing and the shield can each be a one-piece structure unitarily molded from the polymer composition. Likewise, the shield can be a two-piece structure that includes a first shell and a second shell, each of which may be formed from the polymer composition of the present invention.

[0078] Of course, the polymer composition may also be used in a wide variety of other components. For example, the polymer composition may be molded into a planar substrate for use in an electronic component. The substrate may be thin, such as having a thickness of about 500 micrometers or less, in some embodiments from about 50 to about 450 micrometers, and in some embodiments, from about 100 to about 400 micrometers. In one embodiment, for example, the planar substrate may be applied with one or more conductive elements using a variety of known techniques (e.g., laser direct structuring, electroplating, etc.). The conductive elements may serve a variety of different purposes. In one embodiment, for example, the conductive elements form an integrated circuit, such as those used in SIM cards. In another embodiment, the conductive elements form antennas of a variety of different types, such as antennae with resonating elements that are formed from patch antenna structures, inverted-F antenna structures, closed and open slot antenna structures, loop antenna structures, monopoles, dipoles, planar inverted-F antenna structures, hybrids of these designs, etc. The resulting antenna structures may be incorporated into the housing of a relatively compact portable electronic component, such as described above, in which the available interior space is relatively small.

[0079] One particularly suitable electronic component that includes an antenna structure is shown in Figs. 4-5 is a handheld device 410 with cellular telephone capabilities. As shown in Fig. 4, the device 410 may have a housing 412 formed from plastic, metal, other suitable dielectric materials, other suitable conductive materials, or combinations of such materials. A display 414 may be

provided on a front surface of the device 410, such as a touch screen display. The device 410 may also have a speaker port 440 and other input-output ports. One or more buttons 438 and other user input devices may be used to gather user input. As shown in Fig. 5, an antenna structure 426 is also provided on a rear surface 442 of device 410, although it should be understood that the antenna structure can generally be positioned at any desired location of the device. As indicated above, the antenna structure 426 may contain a planar substrate that is formed from the polymer composition of the present invention. The antenna structure may be electrically connected to other components within the electronic device using any of a variety of known techniques. For example, the housing 412 or a part of housing 412 may serve as a conductive ground plane for the antenna structure 426.

[0080] A planar substrate that is formed from the polymer composition of the present invention may also be employed in other applications. For example, in one embodiment, the planar substrate may be used to form a base of a compact camera module ("CCM"), which is commonly employed in wireless communication devices (e.g., cellular phone). Referring to Figs. 6-7, for example, one particular embodiment of a compact camera module 500 is shown in more detail. As shown, the compact camera module 500 contains a lens assembly 504 that overlies a base 506. The base 506, in turn, overlies an optional main board 508. Due to their relatively thin nature, the base 506 and/or main board 508 are particularly suited to be formed from the polymer composition of the present invention as described above. The lens assembly 504 may have any of a variety of configurations as is known in the art, and may include fixed focus-type lenses and/or auto focus-type lenses. In one embodiment, for example, the lens assembly 504 is in the form of a hollow barrel that houses lenses 604, which are in communication with an image sensor 602 positioned on the main board 508 and controlled by a circuit 601. The barrel may have any of a variety of shapes, such as rectangular, cylindrical, etc. In certain embodiments, the barrel may also be formed from the polymer composition of the present invention and have a wall thickness within the ranges noted above. It should be understood that other parts of the camera module may also be formed from the polymer composition of the present invention. For example, as shown, a polymer

film 510 (e.g., polyester film) and/or thermal insulating cap 502 may cover the lens assembly 504. In some embodiments, the film 510 and/or cap 502 may also be formed from the polymer composition of the present invention.

[0081] Yet other possible electronic components that may employ the polymer composition include, for instance, cellular telephones, laptop computers, small portable computers (e.g., ultraportable computers, netbook computers, and tablet computers), wrist-watch devices, pendant devices, headphone and earpiece devices, media players with wireless communications capabilities, handheld computers (also sometimes called personal digital assistants), remote controllers, global positioning system (GPS) devices, handheld gaming devices, battery covers, speakers, camera modules, integrated circuits (e.g., SIM cards), housings for electronic devices, electrical controls, circuit breakers, switches, power electronics, printer parts, etc.

[0082] The present invention may be better understood with reference to the following examples.

Test Methods

[0083] *Comparative Tracking Index ("CTI"):* The comparative tracking index (CTI) is determined in accordance with International Standard IEC 60112-2003-01 and provides a quantitative indication of the ability of a composition to perform as an electrical insulating material under wet and/or contaminated conditions. In determining the CTI rating of a composition, two electrodes are placed on a molded test specimen. A voltage differential is then established between the electrodes while a 0.1% aqueous ammonium chloride solution is dropped onto a test specimen. The maximum voltage at which five (5) specimens withstand the test period for 50 drops without failure is determined. The test voltages range from 100 to 600 V in 25 V increments. The numerical value of the voltage that causes failure with the application of fifty (50) drops of the electrolyte is the "comparative tracking index." The value provides an indication of the relative track resistance of the material. An equivalent method for determining the CTI is ASTM D-3638-12.

[0084] *Melt Viscosity:* The melt viscosity (Pa-s) may be determined in accordance with ISO Test No. 11443 at a shear rate of 1000 s^{-1} and temperature 15°C above the melting temperature (e.g., 350°C) using a Dynisco LCR7001 capillary rheometer. The rheometer orifice (die) had a diameter of 1 mm, length of

20 mm, L/D ratio of 20.1, and an entrance angle of 180°. The diameter of the barrel was 9.55 mm + 0.005 mm and the length of the rod was 233.4 mm.

[0085] *Melting Temperature:* The melting temperature ("T_m") was determined by differential scanning calorimetry ("DSC") as is known in the art. The melting temperature is the differential scanning calorimetry (DSC) peak melt temperature as determined by ISO Test No. 11357. Under the DSC procedure, samples were heated and cooled at 20°C per minute as stated in ISO Standard 10350 using DSC measurements conducted on a TA Q2000 Instrument.

[0086] *Deflection Temperature Under Load ("DTUL"):* The deflection under load temperature was determined in accordance with ISO Test No. 75-2 (technically equivalent to ASTM D648-07). More particularly, a test strip sample having a length of 80 mm, thickness of 10 mm, and width of 4 mm was subjected to an edgewise three-point bending test in which the specified load (maximum outer fibers stress) was 1.8 Megapascals. The specimen was lowered into a silicone oil bath where the temperature is raised at 2°C per minute until it deflects 0.25 mm (0.32 mm for ISO Test No. 75-2).

[0087] *Tensile Modulus, Tensile Stress, and Tensile Elongation:* Tensile properties are tested according to ISO Test No. 527 (technically equivalent to ASTM D638). Modulus and strength measurements are made on the same test strip sample having a length of 80 mm, thickness of 10 mm, and width of 4 mm. The testing temperature is 23°C, and the testing speeds are 1 or 5 mm/min.

[0088] *Flexural Modulus, Flexural Stress, and Flexural Strain:* Flexural properties are tested according to ISO Test No. 178 (technically equivalent to ASTM D790). This test is performed on a 64 mm support span. Tests are run on the center portions of uncut ISO 3167 multi-purpose bars. The testing temperature is 23°C and the testing speed is 2 mm/min.

[0089] *Notched Charpy Impact Strength:* Notched Charpy properties are tested according to ISO Test No. ISO 179-1) (technically equivalent to ASTM D256, Method B). This test is run using a Type A notch (0.25 mm base radius) and Type 1 specimen size (length of 80 mm, width of 10 mm, and thickness of 4 mm). Specimens are cut from the center of a multi-purpose bar using a single tooth milling machine. The testing temperature is 23°C.

EXAMPLE 1

[0090] A sample (Sample 1) is formed from 63.4 wt.% of a liquid crystalline polymer, 18 wt.% glass fibers, 18 wt.% talc, 0.3 wt.% Glycolube™ P, 0.2 wt.% aluminum trihydrate, 0.1 wt.% 4,4'-biphenol, and 0.025 wt.% 2,6-naphthelene dicarboxylic acid. A control sample (Control Sample 1) is also formed from 63.7 wt.% of a liquid crystalline polymer, 18 wt.% glass fibers, 18 wt.% talc, and 0.3 wt.% Glycolube™ P. The liquid crystalline polymer in each of the samples is formed from HBA, HNA, TA, BP, and APAP, such as described in U.S. Patent No. 5,508,374 to Lee, et al. The glass fibers are obtained from Owens Corning and have an initial length of 4 millimeters. Parts are injection molded from Sample 1 and Control Sample 1 and tested for CTI, thermal properties, and mechanical properties. The results are set forth below in Table 1

Table 1

	Sample 1	Control Sample 1
CTI	200	175
Melt Viscosity at 1000 s ⁻¹ and 350°C (Pa-s)	22	36
Melt Viscosity at 400 s ⁻¹ and 350°C (Pa-s)	33	50
DTUL @ 1.8 Mpa (°C)	236.0	232.4
Ten. Brk stress (MPa)	102	117
Ten. Modulus (MPa)	11,618	11,392
Ten. Brk strain (%)	2.5	2.6
Flex Brk stress (MPa)	151	138
Flex modulus (MPa)	13,009	11,767
Flex Brk strain (%)	2.3	2.5
Charpy Notched (KJ/m ²)	8.0	13.7

EXAMPLE 2

[0091] A sample (Sample 2) is formed from 49.7 wt.% of a liquid crystalline polymer, 10 wt.% glass fibers, 15 wt.% talc, 25 wt.% titanium dioxide, 0.3 wt.% Glycolube™ P, 0.2 wt.% aluminum trihydrate, 0.1 wt.% 4,4'-biphenol, and 0.025 wt.% 2,6-naphthelene dicarboxylic acid. A control sample (Control Sample 2) is also formed from 50.0 wt.% of a liquid crystalline polymer, 10 wt.% glass fibers, 15 wt.% talc, 25 wt.% titanium dioxide, and 0.3 wt.% Glycolube™ P. The liquid crystalline polymer in each of the samples is formed from HBA, HNA, TA, BP, and APAP, such as described in U.S. Patent No. 5,508,374 to Lee, et al. The glass fibers are obtained from Owens Corning and have an initial length of 4 millimeters. Parts are injection molded from Sample 2 and Control Sample 2 and

tested for CTI, thermal properties, and mechanical properties. The results are set forth below in Table 2.

Table 2

	Sample 2	Control Sample 2
CTI	300	225
Melt Viscosity at 1000 s ⁻¹ and 350°C (Pa-s)	30	44
Melt Viscosity at 400 s ⁻¹ and 350°C (Pa-s)	44	65
DTUL @ 1.8 Mpa (°C)	224.0	227.0
Ten. Brk stress (MPa)	113	114
Ten. Modulus (MPa)	11,505	11,618
Ten. Brk strain (%)	2.6	2.6
Flex Brk stress (MPa)	140	143
Flex modulus (MPa)	12,025	12,838
Flex Brk strain (%)	2.5	2.6
Charpy Notched (KJ/m ²)	5.0	6.0

EXAMPLE 3

[0092] Seven samples (Samples 3-9) are formed from various percentages of a liquid crystalline polymer, glass fibers, talc, titanium dioxide, Glycolube™ P, aluminum trihydrate ("ATH"), 4,4'-biphenol ("BP"), and 2,6-naphthelene dicarboxylic acid ("NDA") as set forth in Table 3 below.

Table 3

Sample	3	4	5	6	7	8	9
Glycolube™ P (wt.%)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
LCP (wt.%)	63.7	54.7	54.7	54.7	49.7	49.7	49.7
Glass Fibers (wt.%)	18	10	10	10	10	10	10
ATH (wt.%)	0.2	0.2	0.2	0.2	0.2	0.2	0.2
BP (wt.%)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NDA (wt.%)	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Talc (wt.%)	18	10	5	-	15	10	5
TiO ₂ (wt.%)	-	25	30	35	25	30	35

[0093] The liquid crystalline polymer in each of the samples is formed from HBA, HNA, TA, BP, and APAP, such as described in U.S. Patent No. 5,508,374 to Lee, et al. The glass fibers are obtained from Owens Corning and have an initial length of 4 millimeters. Parts are injection molded from the samples and tested for CTI, thermal properties, and mechanical properties. The results are set forth below in Table 4.

Table 4

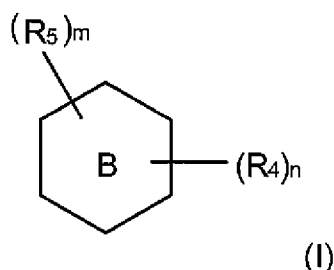
Sample	3	4	5	6	7	8	9
CTI	175	250	300	350	300	300	250
Melt Viscosity at	24	27	33	26	32	28	28

1000 s ⁻¹ and 350°C (Pa-s)							
Melt Viscosity at 400 s ⁻¹ and 350°C (Pa-s)	31	38	49	39	48	43	43
DTUL @ 1.8 Mpa (°C)	227	227	224	221	226	224	222
Ten. Brk stress (MPa)	114	116	132	135	109	118	119
Ten. Modulus (MPa)	11,074	11,312	11,535	12,051	11,558	11,637	11,569
Ten. Brk strain (%)	2.7	2.5	2.9	2.4	2.3	2.7	2.5
Flex Brk stress (MPa)	140	142	145	149	138	143	146
Flex modulus (MPa)	12,418	12,243	12,019	12,195	12,560	12,557	12,273
Flex Brk strain (%)	2.5	2.5	2.5	2.5	2.4	2.6	2.6
Charpy Notched (KJ/m ²)	8	13	17	22	4	5	12

[0094] These and other modifications and variations of the present invention may be practiced by those of ordinary skill in the art, without departing from the spirit and scope of the present invention. In addition, it should be understood that aspects of the various embodiments may be interchanged both in whole or in part. Furthermore, those of ordinary skill in the art will appreciate that the foregoing description is by way of example only, and is not intended to limit the invention so further described in such appended claims.

WHAT IS CLAIMED IS:

1. A polymer composition that comprises from about 20 wt.% to about 90 wt.% of at least one thermotropic liquid crystalline polymer, from about 1 wt.% to about 60 wt.% of inorganic particles, and from about 0.001 wt.% to about 5 wt.% of at least one functional aromatic compound having the general structure provided below in Formula (I):



or a metal salt thereof, wherein,

ring B is a 6-membered aromatic ring wherein 1 to 3 ring carbon atoms are optionally replaced by nitrogen or oxygen, wherein each nitrogen is optionally oxidized, and wherein ring B may be optionally fused or linked to a 5- or 6-membered aryl, heteroaryl, cycloalkyl, or heterocyclyl;

R₄ is OH or COOH;

R₅ is acyl, acyloxy, acylamino, alkoxy, alkenyl, alkyl, amino, aryl, aryloxy, carboxyl, carboxyl ester, cycloalkyl, cycloalkyloxy, hydroxyl, halo, haloalkyl, heteroaryl, heteroaryloxy, heterocyclyl, or heterocycloxy;

m is from 0 to 4; and

n is from 1 to 3,

wherein the polymer composition has a comparative tracking index of about 225 volts or more, as determined in accordance with IEC 60112-2003-01.

2. The polymer composition of claim 1, wherein the functional aromatic compound includes a phenolic compound, diphenolic compound, naphthenic compound, or a combination thereof.

3. The polymer composition of claim 1 or 2, wherein the functional aromatic compound includes an aromatic diol.

4. The polymer composition of claim 3, wherein the aromatic diol is 4,4'-biphenol.

5. The polymer composition of any of the foregoing claims, wherein the functional aromatic compound includes an aromatic carboxylic acid.

6. The polymer composition of any of the foregoing claims, wherein the aromatic carboxylic acid is 2,6-naphthelene dicarboxylic acid.

7. The polymer composition of any of the foregoing claims, wherein the composition includes from about 0.01 wt.% to about 1 wt.% of at least one aromatic diol and from about 0.001 wt.% to about 0.5 wt.% of at least one aromatic dicarboxylic acid.

8. The polymer composition of any of the foregoing claims, wherein the composition further includes at least one non-aromatic functional compound.

9. The polymer composition of claim 8, wherein the non-aromatic functional compound is a hydrate.

10. The polymer composition of any of the foregoing claims, wherein the inorganic particles include titanium dioxide.

11. The polymer composition of any of the foregoing claims, wherein the composition has a comparative tracking index of about 275 volts or more.

12. The polymer composition of any of the foregoing claims, wherein functional aromatic compounds constitute from about 0.05 wt.% to about 0.5 wt.% of the composition, inorganic particles constitute from about 15 wt.% to about 50 wt.% of the composition, and liquid crystalline polymers constitute from about 40 wt.% to about 70 wt.% of the composition.

13. The polymer composition of any of the foregoing claims, wherein the composition has a melt viscosity of from about 0.1 to about 80 Pa-s, as determined in accordance with ISO Test No. 11443 at a shear rate of 1000 seconds⁻¹ and temperature that is 15°C above the melting temperature of the composition.

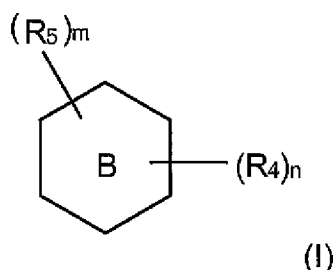
14. The polymer composition of any of the foregoing claims, wherein the polymer contains monomer units derived from 4-hydroxybenzoic acid, terephthalic acid, hydroquinone, 4,4'-biphenol, acetaminophen, 6-hydroxy-2-naphthoic acid, 2,6-naphthelene dicarboxylic acid, or a combination thereof.

15. The polymer composition of any of the foregoing claims, wherein the composition further comprises a mineral filler.

16. The polymer composition of any of the foregoing claims, wherein the composition further comprises glass fibers.

17. A molded part comprising the polymer composition of any of the foregoing claims.

18. An electronic component that comprises a polymer composition, wherein the polymer composition comprises at least one thermotropic liquid crystalline polymer, inorganic particles, and at least one functional aromatic compound having the general structure provided below in Formula (I):



or a metal salt thereof, wherein,

ring B is a 6-membered aromatic ring wherein 1 to 3 ring carbon atoms are optionally replaced by nitrogen or oxygen, wherein each nitrogen is optionally oxidized, and wherein ring B may be optionally fused or linked to a 5- or 6-membered aryl, heteroaryl, cycloalkyl, or heterocyclyl;

R_4 is OH or COOH;

R_5 is acyl, acyloxy, acylamino, alkoxy, alkenyl, alkyl, amino, aryl, aryloxy, carboxyl, carboxyl ester, cycloalkyl, cycloalkyloxy, hydroxyl, halo, haloalkyl, heteroaryl, heteroaryloxy, heterocyclyl, or heterocycloxy;

m is from 0 to 4; and

n is from 1 to 3,

wherein the polymer composition has a comparative tracking index of about 225 volts or more, as determined in accordance with IEC 60112-2003-01.

19. The electronic component of claim 18, wherein the functional aromatic compound includes an aromatic diol.

20. The electronic component of claim 19, wherein the aromatic diol is 4,4'-biphenol.

21. The electronic component of claim 18, wherein the functional aromatic compound includes an aromatic carboxylic acid.

22. The electronic component of claim 18, wherein the aromatic carboxylic acid is 2,6-naphthelene dicarboxylic acid.

23. The electronic component of claim 18, wherein the composition includes from about 0.01 wt.% to about 1 wt.% of at least one aromatic diol and from about 0.001 wt.% to about 0.5 wt.% of at least one aromatic dicarboxylic acid.

24. The electronic component of claim 18, wherein the composition further includes at least one non-aromatic functional compound.

25. The electronic component of claim 18, wherein the inorganic particles include titanium dioxide.

26. The electronic component of claim 18, wherein the composition has a comparative tracking index of about 275 volts or more.

27. The electronic component of claim 18, wherein liquid crystalline polymers constitute from about 20 wt.% to about 90 wt.% of the composition, inorganic particles constitute from about 1 wt.% to about 60 wt.% of the composition, and functional aromatic compounds constitute from about 0.001 wt.% to about 5 wt.% of the composition.

28. The electronic component of claim 18, wherein the composition has a melt viscosity of from about 0.1 to about 80 Pa-s, as determined in accordance with ISO Test No. 11443 at a shear rate of 1000 seconds⁻¹ and temperature that is 15°C above the melting temperature of the composition.

29. The electronic component of claim 18, wherein the composition further comprises a mineral filler.

30. The electronic component of claim 18, wherein the composition further comprises glass fibers.

31. The electronic component of claim 18, wherein the component is an electrical connector that comprises opposing walls between which a passageway is defined for receiving a contact pin, wherein at least one of the walls contains the polymer composition.

32. The electronic component of claim 18, wherein the electronic component is a cellular telephone, laptop computer, small portable computer, wrist-watch device, pendant device, headphone or earpiece device, media player with wireless communications capabilities, handheld computer, remote controller,

global positioning system, handheld gaming device, battery cover, speaker, integrated circuit, electrical connector, camera module, housing, electrical control, circuit breaker, switch, power electronics, printer part, or a combination thereof.

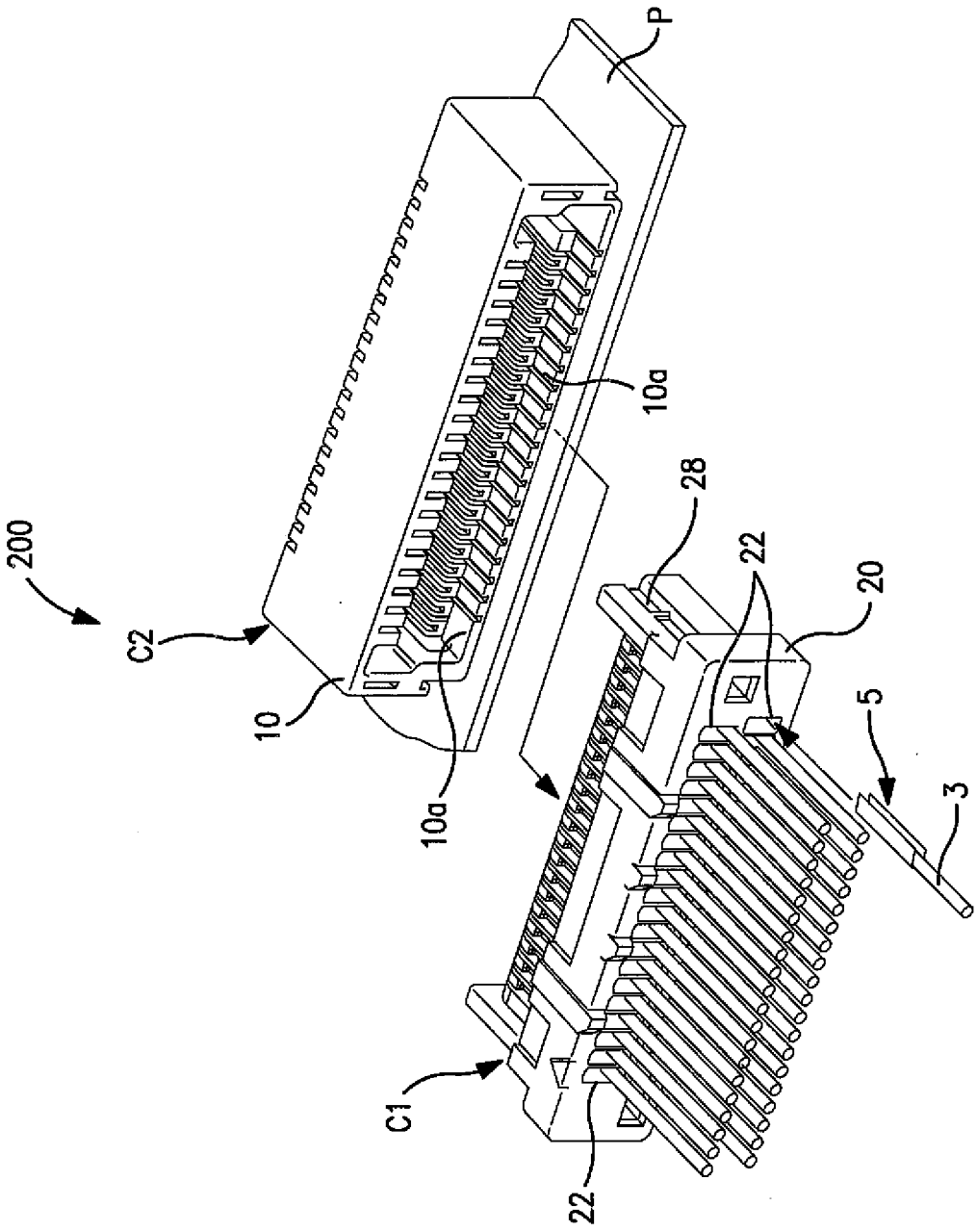


FIG. 1

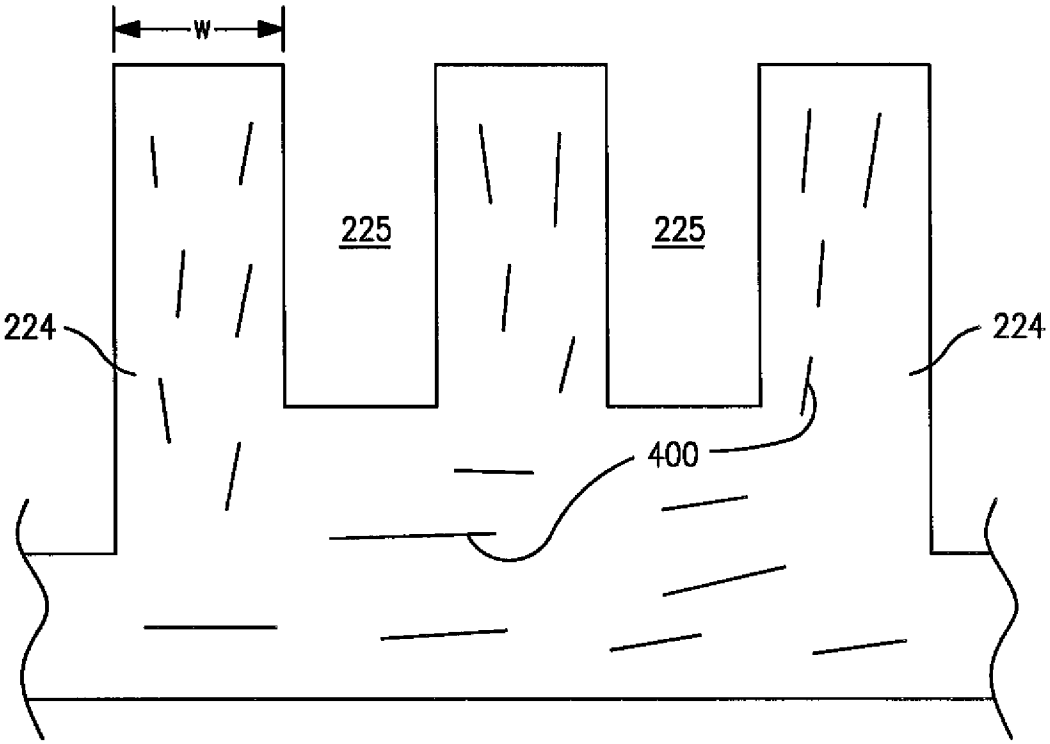


FIG. 2

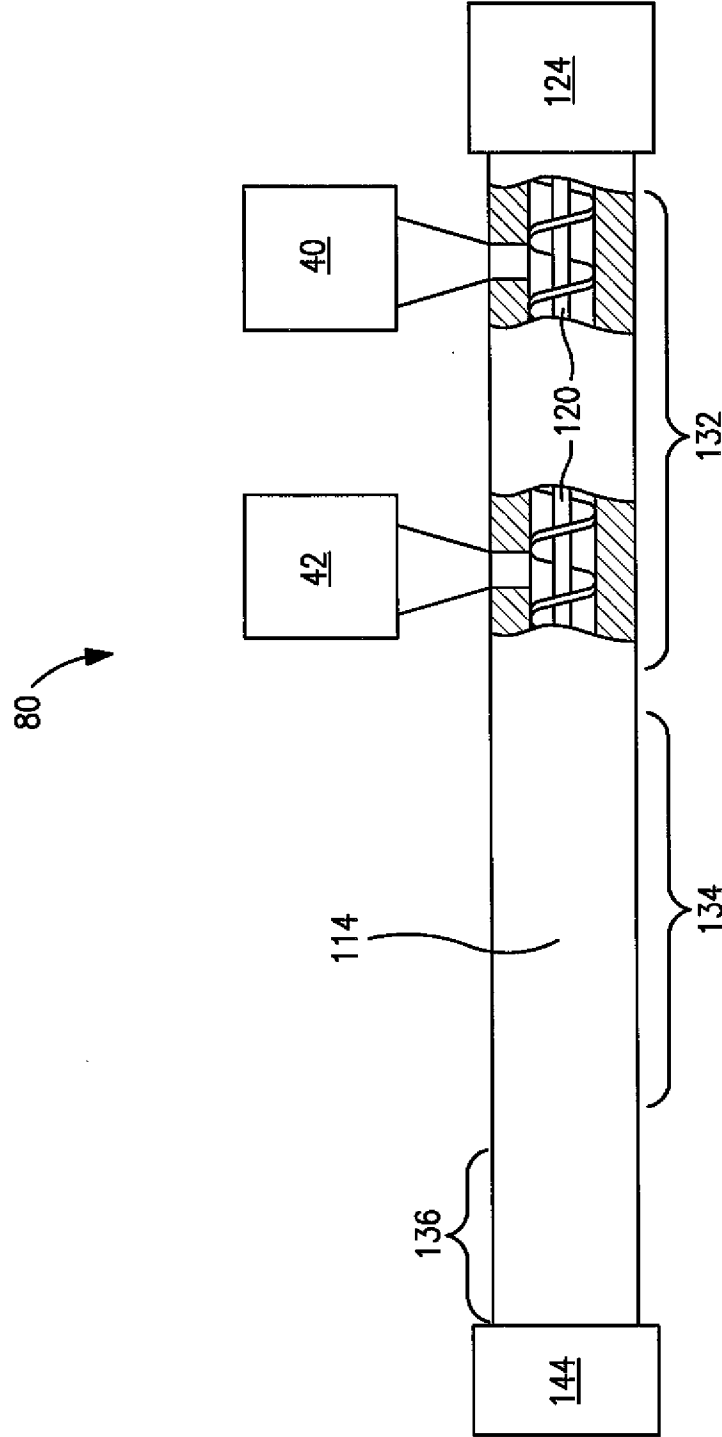


FIG. 3

4/5

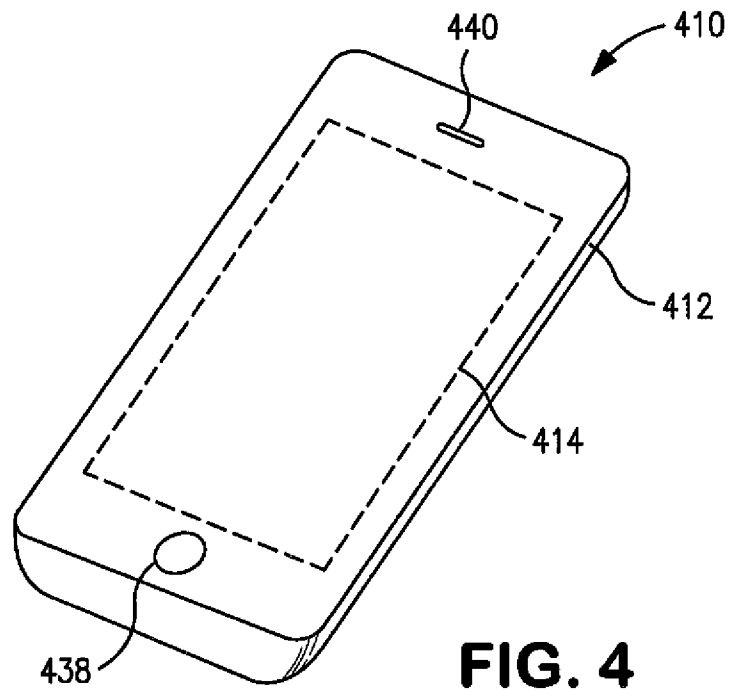


FIG. 4

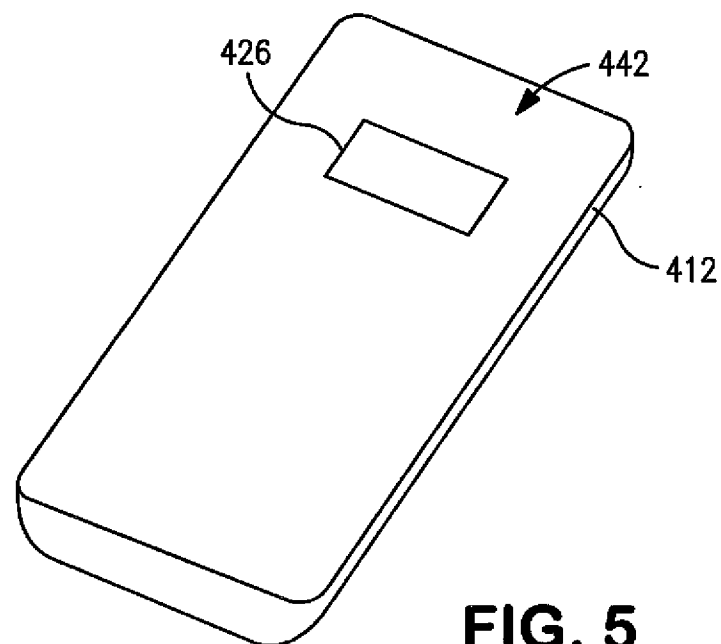


FIG. 5

5/5

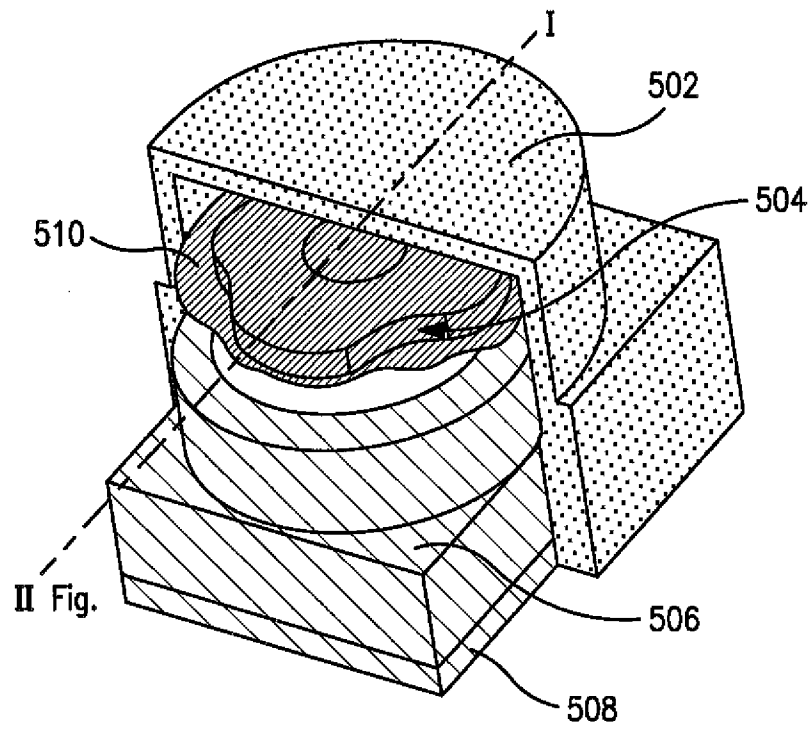


FIG. 6

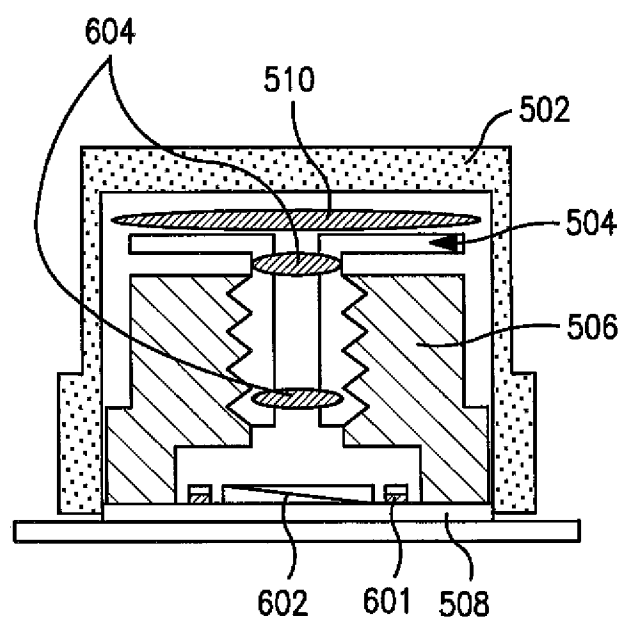


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/064750

A. CLASSIFICATION OF SUBJECT MATTER
 INV. C08G63/60 C08G63/91 C09K19/38
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C08G C09K

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 792 942 A1 (POLYPLASTICS CO [JP]) 6 June 2007 (2007-06-06) paragraphs [0001], [0006], [0034] - [0036], [0044], [0052], [0053] manufacture example 2; tables 1,2	1-32
X	WO 95/33803 A1 (HOECHST CELANESE CORP [US]) 14 December 1995 (1995-12-14) claims 1-19; examples C-8; tables 1,2	1-17
X	US 2005/113555 A1 (OKAMOTO SATOSHI [JP] ET AL) 26 May 2005 (2005-05-26) example 7; table 1 paragraphs [0102], [0106], [0163]; claims 1-6	18-32
	----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 March 2013

Date of mailing of the international search report

20/03/2013

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Schoenhentz, Jérôme

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/064750

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 710 237 A (WAGGONER MARION GLEN [US] ET AL) 20 January 1998 (1998-01-20) examples 2-8; table 1 column 1, lines 8-20 column 3, lines 11-17 column 4, lines 44-49 -----	18-32
X	US 2010/271268 A1 (HOSODA TOMOYA [JP] ET AL) 28 October 2010 (2010-10-28) paragraphs [0012], [0035]; claims 1-9; examples 5-8,12; tables 2,3 -----	18-32
A	US 2005/260372 A1 (MATSUOKA SEIICHI [JP] ET AL) 24 November 2005 (2005-11-24) claims 1-12 production example 2,3; tables 1-5 paragraphs [0073], [0096] -----	1-32
A	US 2010/041855 A1 (HOSODA TOMOYA [JP] ET AL) 18 February 2010 (2010-02-18) production examples 1-6; table 1 paragraph [0056] -----	1-32

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/064750

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
EP 1792942	A1	06-06-2007	CN	101006138 A		25-07-2007
			EP	1792942 A1		06-06-2007
			KR	20070059070 A		11-06-2007
			US	2008139754 A1		12-06-2008
			WO	2006025538 A1		09-03-2006

WO 9533803	A1	14-12-1995	EP	0764195 A1		26-03-1997
			JP	H10501277 A		03-02-1998
			WO	9533803 A1		14-12-1995

US 2005113555	A1	26-05-2005	CN	1629255 A		22-06-2005
			KR	20050043649 A		11-05-2005
			TW	I359159 B		01-03-2012
			US	2005113555 A1		26-05-2005

US 5710237	A	20-01-1998	NONE			

US 2010271268	A1	28-10-2010	CN	101932654 A		29-12-2010
			JP	2009155623 A		16-07-2009
			KR	20100105644 A		29-09-2010
			TW	200940642 A		01-10-2009
			US	2010271268 A1		28-10-2010

US 2005260372	A1	24-11-2005	EP	1623813 A1		08-02-2006
			JP	4431006 B2		10-03-2010
			JP	2006043941 A		16-02-2006
			US	2005260372 A1		24-11-2005

US 2010041855	A1	18-02-2010	CN	101649043 A		17-02-2010
			JP	2010043380 A		25-02-2010
			KR	20100020915 A		23-02-2010
			TW	201022326 A		16-06-2010
			US	2010041855 A1		18-02-2010
