temperature is recommended to be set at 180°C when the glass transition temperature is about 220°C.

[0023] Other problems encountered in more demanding end uses exposed to harsh chemicals, water and/or steam, include problems associated with a plasticizer effect caused when the polymer absorbs the chemical which can enhance motion of molecular chains and create a depression of the glass transition temperature from its normal state in the unswollen polymer.

[0024] A further issue is associated with creep. When polymers operate above their glass transition temperature, creep is a limiting factor for seal components which can deform under harsh conditions. Thus, to improve mechanical properties, prevent creep and resist extrusion, most high temperature polymers in use are filled for use as backup rings or molded components. The downside of use of fillers is that it typically drops the ductility tremendously. For example, unfilled PEEK has a tensile elongation of about 40%, whereas 30% carbon-filled PEEK has a tensile elongation at break of only 1.7%. Thus the material becomes more brittle from the strengthening filler, and the brittleness can result in part cracking under prolonged loadings. The use of fillers also causes a differential coefficient of thermal expansion in the mold versus the transverse direction of the molded parts. This can also cause significant molded-in stress. The end result is cracking over time due to creep rupture, even when a part is not under a significant load.

[0025] Thus, there is a need in the art for better and higher performing polymeric materials for sealing components, seal connectors and similar parts that can operate at high service temperatures associated with oilfield and other harsh conditions and industrial uses, but still maintain good mechanical performance, resist extrusion of the seal or connector material into a gap between two surfaces to be sealed or along the pin, and resist creep when in use, without becoming brittle and significantly losing its ductility.

BRIEF SUMMARY

[0026] ~~In one aspect of t~~The present disclosure~~, there is~~ provide~~s~~d a composition for formation of an extrusion-resistant sealing member, comprising: an aromatic polymer; and a crosslinking compound. The polymer may be one or more of a polyarylene polymer, a polysulfone, a polyphenylene sulfide, a polyimide, a polyamide, a polyurea, a polyurethane, a polythalamide, a polyamide-imide, an aramid, a polybenzimidazole, and blends, copolymers and derivatives thereof. Preferably, the aromatic

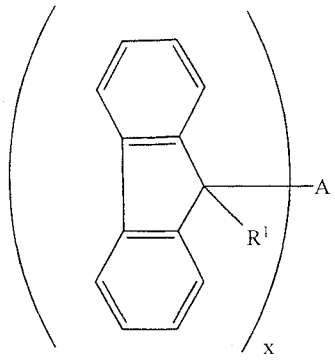
polymer is a polyarylene polymer and/or a polysulfone polymer, and blends, copolymers and derivatives thereof.

[0026a] In one aspect of the present disclosure, there is provided a composition when used in the formation of an extrusion-resistant sealing member, comprising:

an aromatic polymer; and

a crosslinking compound,

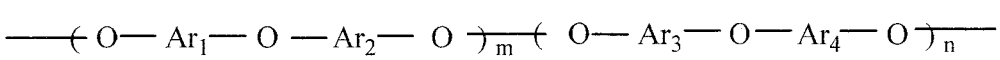
wherein said crosslinking compound has a structure according to formula (II) below:



(II)

wherein A is an arene moiety having a molecular weight of less than 10,000 g/mol, R^1 is elected from a group consisting of hydroxide (-OH), amine ($-NH_2$), halide, ether, ester, or amide, and x = 2.0 to 6.0.

[0027] When the aromatic polymer is a polyarylene ether polymer, it may have repeating having units of structure according to formula (IV) below:

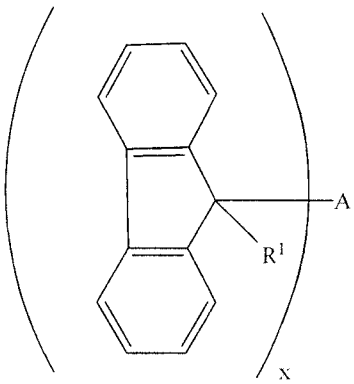


(IV)

wherein Ar_1, Ar_2, Ar_3 and Ar_4 are identical or different aryl radicals, m is 0 to 1, and n is 1 - m.

[0028] If the aromatic polymer is a polyarylene-type polymer, it is preferably at least one of polyetheretherketone, polyetherketone, polyetherketoneetherketoneketone, polyetherketoneketone, polysulfone, polyphenylene sulfide, polyethersulfone, polyarylsulfone, and blends, copolymers and derivatives thereof.

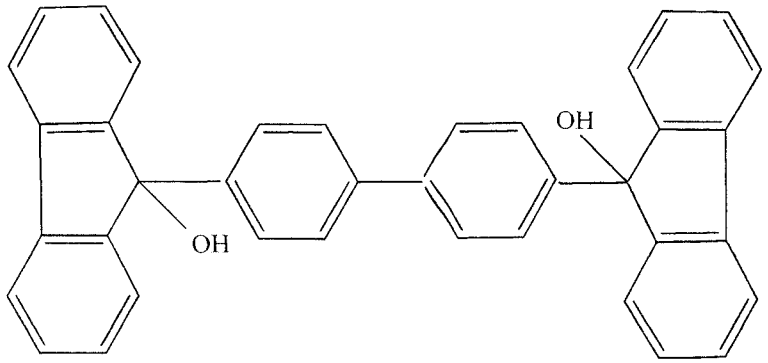
[0029] The crosslinking compound preferably has a structure according to formula (II) below:



(II)

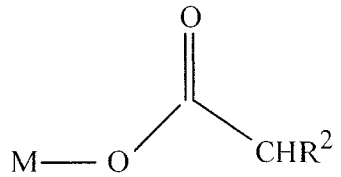
wherein A is an arene moiety having a molecular weight of less than 10,000 g/mol, R^1 is selected from a group consisting of hydroxide (-OH), amine ($-NH_2$), halide, ether, ester, or amide, and x = 2.0 to 6.0.

[0030] The crosslinking compound is preferably 9,9'-(biphenyl-4,4'-diyl)bis(9H-fluoren-9-ol) and has a general structure according to formula (V):



(V)

[0031] The composition noted above may also include a cross-linking reaction additive capable of reacting with the cross-linking compound to form a reactive intermediate in the form of an oligomer, which reactive intermediate oligomer is capable of cross-linking an organic polymer. The cross-linking reaction additive may be an organic acid which may be glacial acetic acid, formic acid, and/or benzoic acid. In another embodiment, the cross-linking reaction additive may be an acetate compound that has a structure according to formula (III):



(III)

wherein M is a Group I or a Group II metal; and R^2 is an alkyl, aryl, or aralkyl group, wherein the alkyl group is a hydrocarbon group of 1 to about 15 carbon atoms having 0 to about 5 ester or ether groups along or in the chain of the hydrocarbon group, wherein R^2 has 0 to about 5 functional groups.

[0032] Preferably, the compositions of the present disclosure are unfilled compositions providing enhanced ductility in use, although, they may be filled if the user desires to fill the composition.

[0033] ~~In another aspect of t~~The present disclosure also ~~, there is~~ provide~~s~~d sealing components of a sealing assembly formed by a method comprising the step of crosslinking a composition as described herein.

[0034] ~~In a further aspect of t~~The present disclosure further~~, there is~~ provide~~s~~d a sealing connector having a seal connector body formed by a method comprising the step of crosslinking a composition as described herein.

[0035] ~~In a further aspect of t~~The present disclosure also~~, there is~~ provide~~s~~d a method of improving extrusion- and creep-resistance of a component for use in a high temperature sealing element or seal connector, comprising, providing a composition comprising an aromatic polymer and a crosslinking

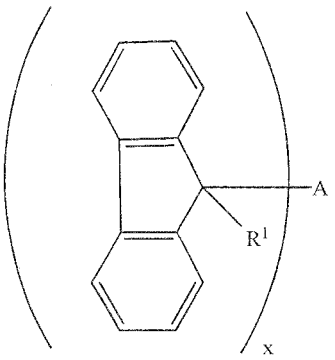
compound, and subjecting the composition to a heat molding process to form the component and crosslink the aromatic polymer. The composition is preferably unfilled. The aromatic polymer and cross-linking compound may be any of those noted herein and described above, and the composition may also include the optional cross-linking reaction additive.

[0035a] In another aspect of the present disclosure, there is provided a method of improving extrusion- and creep-resistance of a component for use in a high temperature sealing element or seal connector, comprising,

providing a composition comprising an aromatic polymer and a crosslinking compound, and

subjecting the composition to a heat molding process to form the component and crosslink the aromatic polymer,

wherein said crosslinking compound has a structure according to formula (II) below:



(II)

wherein A is an arene moiety having a molecular weight of less than 10,000 g/mol, R^1 is selected from a group consisting of hydroxide (-OH), amine ($-NH_2$), halide, ether, ester, or amide, and x = 2.0 to 6.0.

[0036] Also included herein are sealing components and sealing connectors formed by the method described above, wherein the composition may be filled or unfilled. The sealing component is a seal back-up element, a packer element, a labyrinth seal or a dual-lip sealing component.

~~[0036a] In one aspect of the present disclosure, there is provided a sealing component formed by a method as described herein.~~

~~[0036b] In a further aspect of the present disclosure, there is provided a sealing connector formed by a method as described herein.~~

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0037] The foregoing summary, as well as the following detailed description of preferred embodiments of the invention, will be better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, there is shown in the drawings embodiments which are presently preferred. It should be understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown. In the drawings:

[0038] Fig. 1 is a photographic representation of a Prior Art PEEK back-up ring tested at 300°F (149°C) with 21,000 psi applied hydrostatic pressure to the top surface for 24 hours, wherein extrusion of 0.19 mm was measured on the outer edge of the ring;

[0039] Fig. 2 is a photographic representation of the bottom surface of a Prior Art PEEK back-up ring tested at 450°F (237°C) with 11,000 psi applied hydrostatic pressure to the top surface for 24 hours. This loading at high temperature resulted in extrusion of 0.30 mm, a 60% increase in extrusion over that in Fig. 1, but at only one-half the applied pressure;

[0040] Fig. 3 is a Prior Art SealConnect® connector formed of polyether ketone (PEK) before and after application of 20,000 psi hydrostatic pressure and 300°F (149°C) for 24 hours;

[0041] Fig. 4 is a schematic representation of a backup ring extrusion simulation test used in Example 1;

[0042] Fig. 5 is photographic representation of a 17% crosslinked PEEK backup ring cut in cross section, after the 450°F and 40,000 psi functional test for a sample made according to an embodiment of the invention in Example 1 and showing very minor extrusion in the sample;

CLAIMS

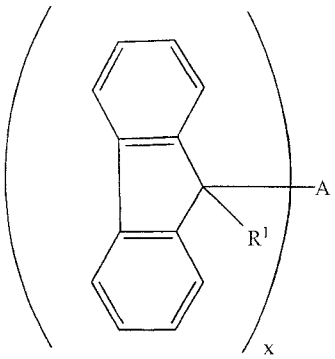
We claim:

1. A composition ~~for~~ when used in the formation of an extrusion-resistant sealing member, comprising:

an aromatic polymer; and

a crosslinking compound,

wherein said crosslinking compound has a structure according to formula (II) below:



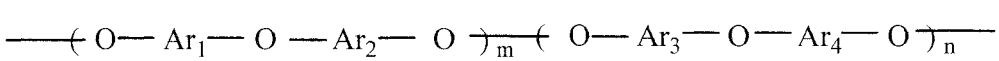
(II)

wherein A is an arene moiety having a molecular weight of less than 10,000 g/mol, R^1 is elected from a group consisting of hydroxide (-OH), amine ($-NH_2$), halide, ether, ester, or amide, and x = 2.0 to 6.0.

2. The composition according to claim 1, wherein the polymer is selected from the group consisting of a polyarylene polymer, a polysulfone, a polyphenylene sulfide, a polyimide, a polyamide, a polyurea, a polyurethane, a polythalamide, a polyamide-imide, an aramid, a polybenzimidazole, and blends, copolymers and derivatives thereof.

3. The composition according to claim 2, wherein the aromatic polymer is a polyarylene polymer and/or a polysulfone polymer, and blends, copolymers and derivatives thereof.

4. The composition according to claim 3, wherein the aromatic polymer is a polyarylene ether polymer including polymer repeating having units of structure according to formula (IV) below:

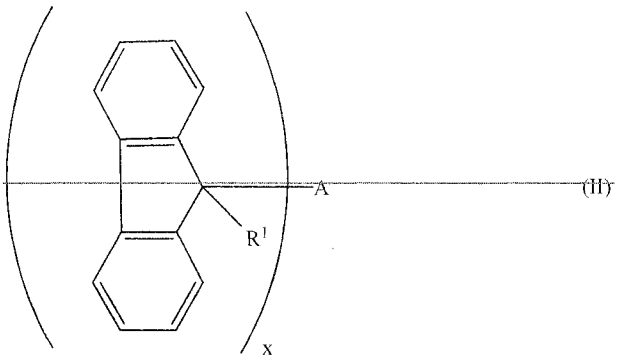


(IV)

wherein Ar_1, Ar_2, Ar_3 and Ar_4 are identical or different aryl radicals, m is 0 to 1, and n is 1 - m.

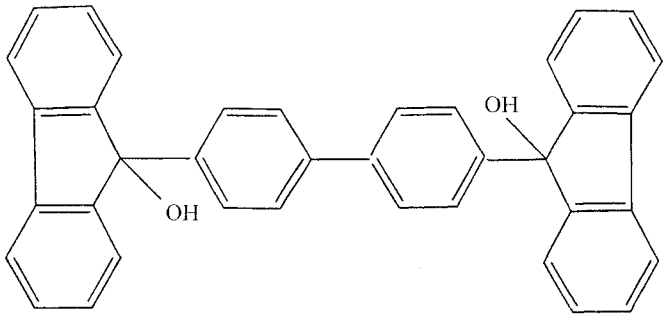
5. The composition according to claim 3, wherein the aromatic polymer is at least one of polyetheretherketone, polyetherketone, polyetherketoneetherketoneketone, polyetherketoneketone, polysulfone, polyphenylene sulfide, polyethersulfone, polyarylsulfone, and blends, copolymers and derivatives thereof.

~~6. The composition according to claim 1, wherein the crosslinking compound has a structure according to formula (II) below:~~



~~wherein A is an arene moiety having a molecular weight of less than 10,000 g/mol, R^1 is selected from a group consisting of hydroxide (-OH), amine ($-NH_2$), halide, ether, ester, or amide, and x = 2.0 to 6.0.~~

~~7~~6. The composition according to claim 1, wherein the crosslinking compound is 9,9'-(biphenyl-4,4'-diyl)bis(9H-fluoren-9-ol) and has a general structure according to formula (V):

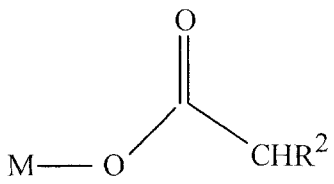


(V)

~~8~~7. The composition according to claim 1, further comprising a cross-linking reaction additive capable of reacting with the cross-linking compound to form a reactive intermediate in the form of an oligomer, which reactive intermediate oligomer is capable of cross-linking an organic polymer.

~~9~~8. The composition according to claim ~~8~~7, wherein the cross-linking reaction additive is an organic acid which is~~may be~~ glacial acetic acid, formic acid, and/or benzoic acid.

~~10~~9. The composition according to claim ~~8~~7, wherein the cross-linking reaction additive is ~~may be~~ an acetate compound that has a structure according to formula (III):



(III)

wherein M is a Group I or a Group II metal; and R^2 is an alkyl, aryl, or aralkyl group, wherein the alkyl group is a hydrocarbon group of 1 to about 15 carbon atoms having 0 to about 5 ester or ether groups along or in the chain of the hydrocarbon group, wherein R^2 has 0 to about 5 functional groups.

~~11~~10. The composition according to claim 1, wherein the composition is an unfilled composition.

~~12. A sealing component of a sealing assembly formed by a method comprising the step of crosslinking a composition according to claim 1.~~

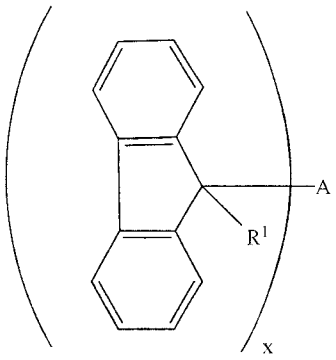
~~13. A sealing connector having a seal connector body formed by a method comprising the step of crosslinking a composition according to claim 1.~~

~~14~~11. A method of improving extrusion- and creep-resistance of a component for use in a high temperature sealing element or seal connector, comprising,

providing a composition comprising an aromatic polymer and a crosslinking compound, and

subjecting the composition to a heat molding process to form the component and crosslink the aromatic polymer,

wherein said crosslinking compound has a structure according to formula (II) below:



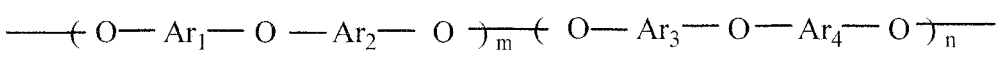
(II)

wherein A is an arene moiety having a molecular weight of less than 10,000 g/mol. R^1 is selected from a group consisting of hydroxide (-OH), amine ($-NH_2$), halide, ether, ester, or amide, and $x = 2.0$ to 6.0.

~~15~~12. The method according to claim ~~14~~11, wherein the composition is unfilled.

~~16~~13. The method according to claim ~~14~~11, wherein the aromatic polymer is selected from the group consisting of a polyarylene polymer, a polysulfone, a polyphenylene sulfide, a polyimide, a polyamide, a polyurea, a polyurethane, a polyththalamide, a polyamide-imide, an aramid, a polybenzimidazole, and blends, copolymers and derivatives thereof.

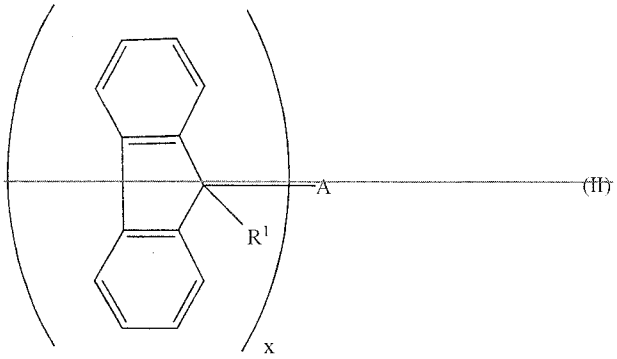
~~17~~14. The method according to claim ~~16~~13, wherein the aromatic polymer is a polyarylene ether polymer including polymer repeating having units of structure according to formula (IV) below:



(IV)

wherein Ar_1, Ar_2, Ar_3 and Ar_4 are identical or different aryl radicals, m is 0 to 1, and n is 1 - m.

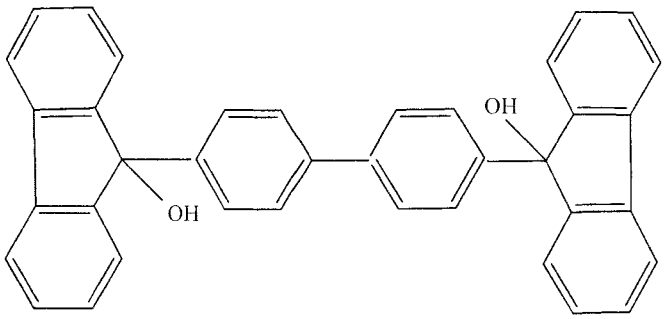
~~18. The method according to claim 14, wherein the crosslinking compound has a structure according to formula (II) below:~~



(II)

~~wherein A is an arene moiety having a molecular weight of less than 10,000 g/mol, R^1 is selected from a group consisting of hydroxide (-OH), amine ($-NH_2$), halide, ether, ester, or amide, and x = 2.0 to 6.0.~~

~~19~~15. The method according to claim ~~14~~11, wherein the crosslinking compound is 9,9'-(biphenyl-4,4'-diyl)bis(9H-fluoren-9-ol) and has a general structure according to formula (V):

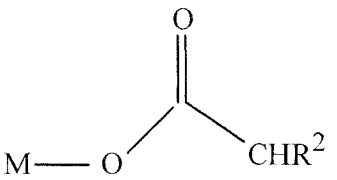


(V)

~~20~~16. The method according to claim ~~14~~11, further comprising a cross-linking reaction additive capable of reacting with the cross-linking compound to form a reactive intermediate in the form of an oligomer, which reactive intermediate oligomer is capable of cross-linking an organic polymer.

~~21~~17. The method according to claim ~~20~~16, wherein the cross-linking reaction additive is an organic acid which is ~~may be~~ glacial acetic acid, formic acid, and/or benzoic acid.

~~22~~18. The method according to claim ~~20~~16, wherein the cross-linking reaction additive is~~may be~~ an acetate compound that has a structure according to formula (III):



(III)

wherein M is a Group I or a Group II metal; and R^2 is an alkyl, aryl, or aralkyl group, wherein the alkyl group is a hydrocarbon group of 1 to about 15 carbon atoms having 0 to about 5 ester or ether groups along or in the chain of the hydrocarbon group, wherein R^2 has 0 to about 5 functional groups.

~~23. A sealing component formed by the method of claim 14.~~

~~24. The sealing component according to claim 23, wherein the composition is unfilled.~~

~~25. The sealing component according to claim 23, wherein the sealing component is a seal back-up element, a packer element, a labyrinth seal or a dual-lip sealing component.~~

~~26. A sealing connector formed by the method of claim 14.~~

~~27. The sealing connector formed by the method of claim 26, wherein the composition is unfilled.~~