

TITLE

STATIC-DISSIPATIVE PFA BLENDS AND USES THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority of U.S. Provisional Application No. 63/449,458 filed March 2, 2023, the disclosures of which are incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates to compositions including a perfluoroalkoxy alkane (PFA). More specifically, this disclosure relates to static-dissipative blends including a PFA and a sulfonated fluoropolymer and apparatus and uses thereof.

BACKGROUND

[0003] Ideal fluid handling systems for semiconductor fabrication are clean and static-dissipative to avoid contamination and static buildup during the pumping of fluids through the fluid handling system during the semiconductor fabrication process. Static buildup is particularly dangerous when working with flammable materials. Static-dissipative materials can prevent static discharge by allowing electric charges to flow slowly and in a more controlled manner through the material.

[0004] The largest application of PFA resins globally is in fluid handling systems for semiconductor fabrication. As noted above, there is a growing need for the materials of these systems, including tubing, valves, fittings, and vessels, to be static-dissipative. Conventionally, static dissipation is achieved with electrically conductive carbon black as a filler in a polymeric material such as PFA, which is not static-dissipative without the carbon black filler. However, carbon black is not preferred in semiconductor fabrications due to cleanliness concerns and also the desire for materials having optical transparency. Carbon black is sometimes included in stripes in the PFA to address the transparency issue.

[0005] There is a need for clean, transparent, static-dissipative PFA compounds.

SUMMARY OF THE INVENTION

[0006] Compositions, methods, and articles disclosed herein provide polymer blends of a PFA and a sulfonated fluoropolymer, provide static dissipative polymer blends, provide transparent polymer blends, provide static dissipative conduits, provide static dissipative coatings, provide transparent conduits, provide transparent coatings, provide clean conduits, provide clean coatings, provide metal absorption, provide metal ion absorption, or combinations thereof.

[0007] In one embodiment, a composition comprises a polymer blend comprising at least 15 wt% of a sulfonated fluoropolymer and at least 50 wt% of a perfluoroalkoxy alkane.

[0008] In one embodiment of the composition, the polymer blend comprises 15 wt% to about 35 wt% of the sulfonated fluoropolymer and about 65 wt% to 85 wt% of the perfluoroalkoxy alkane.

[0009] In another embodiment of the composition, the sulfonated fluoropolymer and the perfluoroalkoxy alkane are at least 99%, by weight, of the polymer blend.

[0010] In another embodiment of the composition, the polymer blend consists essentially of the sulfonated fluoropolymer and the perfluoroalkoxy alkane.

[0011] In another embodiment of the composition, the polymer blend is free of carbon black.

[0012] In another embodiment of the composition, the sulfonated fluoropolymer is a copolymer of tetrafluoroethylene and a sulfonated perfluoroether.

[0013] In another embodiment of the composition, the sulfonated perfluoroether comprises perfluoro-3,6-dioxa-4-methyl-7-octenesulfonyl fluoride.

[0014] In another embodiment of the composition, the sulfonated fluoropolymer comprises a perfluorosulfonic acid polymer and the sulfonated perfluoroether comprises a perfluoroether sulfonic acid.

[0015] In another embodiment of the composition, the perfluoroether sulfonic acid comprises perfluoro-3,6-dioxa-4-methyl-7-octenesulfonic acid.

[0016] In another embodiment of the composition, the perfluoroalkoxy alkane is a copolymer of tetrafluoroethylene and a perfluoroalkylether.

[0017] In another embodiment of the composition, the perfluoroalkylether is selected from the group consisting of perfluoromethyl ether, perfluoroethyl ether, perfluoropropyl ether, and combinations thereof.

[0018] In another embodiment of the composition, the composition is static dissipative.

[0019] In another embodiment of the composition, the composition is transparent.

[0020] In another embodiment, a process forms a polymer blend. The process comprises blending a perfluorosulfonyl fluoride polymer with a perfluoroalkoxy alkane to form a polymer composition, wherein the polymer composition comprises at least 15 wt% of the perfluorosulfonyl fluoride polymer and at least 50 wt% of the perfluoroalkoxy alkane. The process also comprises hydrolyzing the polymer composition to convert the perfluorosulfonyl fluoride polymer to a perfluorosulfonic acid polymer, thereby forming the polymer blend.

[0021] In one embodiment of the process of forming, the blending comprises melt extruding the perfluorosulfonyl fluoride polymer with the perfluoroalkoxy alkane.

[0022] In another embodiment of the process of forming, the hydrolyzing the polymer composition comprises exposing the polymer composition to a strong base solution.

[0023] In another embodiment of the process of forming, the polymer composition comprises 15 wt% to about 35 wt% of the perfluorosulfonyl fluoride polymer and about 65 wt% to 85 wt% of the perfluoroalkoxy alkane.

[0024] In another embodiment of the process of forming, the perfluorosulfonyl fluoride polymer and the perfluoroalkoxy alkane are at least 99%, by weight, of the polymer composition.

[0025] In another embodiment of the process of forming, the perfluorosulfonyl fluoride polymer is a copolymer of tetrafluoroethylene and a perfluoroether sulfonyl fluoride.

[0026] In another embodiment of the process of forming, the perfluoroether sulfonyl fluoride comprises perfluoro-3,6-dioxo-4-methyl-7-octenesulfonyl fluoride.

[0027] In another embodiment of the process of forming, the perfluoroalkoxy alkane is a copolymer of tetrafluoroethylene and a perfluoroalkylether.

[0028] In another embodiment of the process of forming, the perfluoroalkylether is selected from the group consisting of perfluoromethyl ether, perfluoroethyl ether, perfluoropropyl ether, and combinations thereof.

[0029] In another embodiment, a method transports a flammable fluid. The method comprises flowing the flammable fluid through a conduit formed by a polymer blend comprising at least 15 wt% of a sulfonated fluoropolymer and at least 50 wt% of a perfluoroalkoxy alkane. The polymer blend is static dissipative and transparent.

[0030] In one embodiment of the process of transporting, the polymer blend comprises 15 wt% to about 35 wt% of the sulfonated fluoropolymer and about 65 wt% to 85 wt% of the perfluoroalkoxy alkane.

[0031] In another embodiment of the process of transporting, the sulfonated fluoropolymer and the perfluoroalkoxy alkane are at least 99%, by weight, of the polymer blend.

[0032] In another embodiment of the process of transporting, the sulfonated fluoropolymer is a copolymer of tetrafluoroethylene and a sulfonated perfluoroether.

[0033] In another embodiment of the process of transporting, the sulfonated perfluoroether comprises perfluoro-3,6-dioxo-4-methyl-7-octenesulfonic acid.

[0034] In another embodiment of the process of transporting, the perfluoroalkoxy alkane is a copolymer of tetrafluoroethylene and a perfluoroalkylether.

[0035] In another embodiment of the process of transporting, the perfluoroalkylether is selected from the group consisting of perfluoromethyl ether, perfluoroethyl ether, perfluoropropyl ether, and combinations thereof.

[0036] In another embodiment, an article comprises a polymer blend of at least 15 wt% of a sulfonated fluoropolymer and at least 50 wt% of a perfluoroalkoxy alkane.

[0037] In one embodiment of the article, the polymer blend comprises 15 wt% to about 35 wt% of the sulfonated fluoropolymer and about 65 wt% to 85 wt% of the perfluoroalkoxy alkane.

[0038] In another embodiment of the article, the sulfonated fluoropolymer and the perfluoroalkoxy alkane are at least 99%, by weight, of the polymer blend.

[0039] In another embodiment of the article, the sulfonated fluoropolymer is a copolymer of tetrafluoroethylene and a sulfonated perfluoroether.

[0040] In another embodiment of the article, the sulfonated perfluoroether comprises perfluoro-3,6-dioxa-4-methyl-7-octenesulfonic acid.

[0041] In another embodiment of the article, the perfluoroalkoxy alkane is a copolymer of tetrafluoroethylene and a perfluoroalkylether.

[0042] In another embodiment of the article, the perfluoroalkylether is selected from the group consisting of perfluoromethyl ether, perfluoroethyl ether, perfluoropropyl ether, and combinations thereof.

[0043] In another embodiment of the article, the article is an item selected from the group consisting of tubing, a valve, a fitting, and a vessel.

[0044] In another embodiment of the article, the polymer blend is a surface coating.

[0045] In another embodiment of the article, the article comprises a surface layer of the polymer blend on a substrate, the substrate having a lower content of the sulfonated fluoropolymer than the polymer blend.

[0046] In another embodiment of the article, the substrate comprises a mixture of perfluoroalkylether and carbon.

[0047] Other features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiments, taken in conjunction with the accompanying drawing which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWING

[0048] Fig. 1 is a schematic cross-sectional view of an article in an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0049] Provided are exemplary static-dissipative blends including a perfluoroalkoxy alkane (PFA) and a sulfonated fluoropolymer. Also provided are methods of forming a blend of a PFA and a sulfonated fluoropolymer and apparatus and uses of the blends.

[0050] As used herein, the term “perfluoroalkoxy alkane (PFA)” refers to any copolymer of tetrafluoroethylene (TFE) and a perfluoroalkylether.

[0051] As used herein, the term “sulfonated fluoropolymer” refers to any copolymer of TFE and a sulfonated perfluoroether.

[0052] As used herein, the term “perfluorosulfonate polymer” refers to any copolymer of TFE and a perfluoroether sulfonate.

[0053] As used herein, the term “perfluorosulfonyl fluoride polymer” refers to any copolymer of TFE and a perfluoroether sulfonyl fluoride.

[0054] As used herein, the term “perfluorosulfonic acid polymer” refers to any copolymer of TFE and a perfluoroether sulfonic acid.

[0055] As used herein, the term “static dissipative” refers to any composition having a surface resistivity of about 10^6 to about 10^{11} ohms.

[0056] In some embodiments, a polymer blend includes at least 15 wt% of a sulfonated fluoropolymer at least 50 wt% of a perfluoroalkoxy alkane, alternatively 15 wt% to about 35 wt% of the sulfonated fluoropolymer and about 65 wt% to 85 wt% of the perfluoroalkoxy alkane, alternatively about 20 wt% to about 30 wt% of the sulfonated fluoropolymer and about 70 wt% to about 80 wt% of the perfluoroalkoxy alkane, or any value, range, or sub-range therebetween.

[0057] In some embodiments, the sulfonated fluoropolymer and the perfluoroalkoxy alkane are at least 95%, by weight, of the polymer blend,

alternatively at least 98%, alternatively at least 99%, alternatively at least 99.5%, alternatively at least 99.9%, or any value, range, or sub-range therebetween.

[0058] In some embodiments, the blend consists essentially of the PFA and the sulfonated fluoropolymer.

[0059] In some embodiments, the blend consists of the PFA and the sulfonated fluoropolymer.

[0060] In some embodiments, the blend is free of any additive that could leach out from the blend and into a fluid stream.

[0061] In some embodiments, the blend is free or essentially free of carbon black.

[0062] In some embodiments, the blend is free or essentially free of any other material with static dissipative properties.

[0063] In some embodiments, the blend is free or essentially free of any additives.

[0064] In some embodiments, the sulfonated fluoropolymer is a sulfonated fluoropolymer sold under the Nafion™ trade name (The Chemours Company FC, LLC, Wilmington, DE). The sulfonated fluoropolymer may have any equivalent weight or ion exchange capacity.

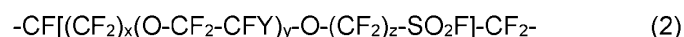
[0065] In some embodiments, the sulfonated fluoropolymer starts as a perfluorosulfonyl fluoride polymer, which is converted to a perfluorosulfonate polymer before being converted to the perfluorosulfonic acid polymer.

[0066] In some embodiments, the perfluorosulfonyl fluoride polymer includes a monomeric unit of perfluoroether sulfonyl fluoride of Formula 1:



where x is 0 or 1 and R is a C₁-C₂₀ perfluoroalkyl group that may be straight chained or branched and may include one or more ether oxygen atoms.

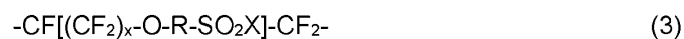
[0067] In some embodiments, the perfluorosulfonyl fluoride polymer includes a monomeric unit of perfluoroether sulfonyl fluoride of Formula 2:



where x is 0 or 1, Y is F or CF₃, y is 0, 1, 2, or 3, and z is 1, 2, 3, or 4.

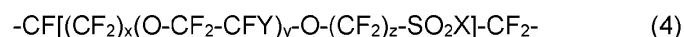
[0068] In some embodiments, z is 1 and the perfluoroether sulfonyl fluoride includes perfluoro-3,6-dioxo-4-methyl-7-octenesulfonyl fluoride.

[0069] In some embodiments, the perfluorosulfonate polymer includes a monomeric unit of sulfonated perfluoroether of Formula 3:



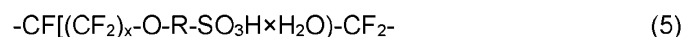
where x and R are the same as in Formula 1 and X is Na or K.

[0070] In some embodiments, the perfluorosulfonate polymer includes a monomeric unit of sulfonated perfluoroether of Formula 4:



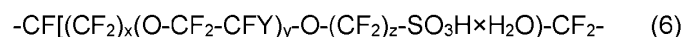
where x, Y, y, and z are the same as in Formula 2 and X is Na or K.

[0071] In some embodiments, the perfluorosulfonic acid polymer includes a monomeric unit of perfluoroether sulfonic acid of Formula 5:



where x and R are the same as in Formula 1.

[0072] In some embodiments, the perfluorosulfonic acid polymer includes a monomeric unit of perfluoroether sulfonic acid of Formula 6:



where x, Y, y, and z are the same as in Formula 2.

[0073] In some embodiments, z is 1 and the perfluoroether sulfonic acid includes perfluoro-3,6-dioxo-4-methyl-7-octenesulfonic acid.

[0074] In some embodiments, the PFA is a PFA sold under the Teflon™ trade name (The Chemours Company FC, LLC, Wilmington, DE).

[0075] In some embodiments, the PFA includes a monomeric unit of perfluoroalkylether of Formula 7:



where n is 0, 1, 2, or 3.

[0076] In some embodiments, the PFA includes a monomeric unit of perfluoromethyl ether, perfluoroethyl ether, perfluoropropyl ether, or combinations thereof.

[0077] In some embodiments, the PFA includes a monomeric unit of perfluoromethyl ether.

[0078] In some embodiments, the PFA includes a monomeric unit of perfluoroethyl ether.

[0079] In some embodiments, the PFA includes a monomeric unit of perfluoropropyl ether.

[0080] In some embodiments, the composition is static dissipative. In some embodiments, the static-dissipative composition has a surface resistivity in the range of about 10^6 to about 10^{11} ohms, alternatively in the range of about 10^6 to about 10^{10} ohms, alternatively in the range of about 10^6 to about 10^9 ohms, alternatively in the range of about 10^6 to about 10^8 ohms, alternatively in the range of about 10^7 to about 10^{11} ohms, alternatively in the range of about 10^7 to about 10^{10} ohms, alternatively in the range of about 10^8 to about 10^{10} ohms, or any value, range, or sub-range therebetween.

[0081] In some embodiments, the composition is transparent.

[0082] In some embodiments, the composition absorbs metals and/or metal ions, such as, for example, from a fluid phase contacting the composition. In some embodiments, the presence of the sulfonated fluoropolymer in the blend provides the composition with the metal and/or metal ion absorption properties.

[0083] In exemplary embodiments, the blend compositions are formed by blending a PFA and a perfluorosulfonyl fluoride polymer. After blending, the perfluorosulfonyl fluoride polymer is hydrolyzed to a perfluorosulfonate polymer, which is then converted to its final form, a perfluorosulfonic acid polymer.

[0084] In some embodiments, the blending includes melt extruding the perfluorosulfonyl fluoride polymer with the perfluoroalkoxy alkane.

[0085] In some embodiments, the hydrolyzing the polymer composition comprises exposing the polymer composition to a strong base solution, such as, for example

potassium hydroxide (KOH). In some embodiments, the exposure is to a solution with about 25 to 50 wt% strong base for about 60 to about 180 minutes at about 80°C to about 99°C.

[0086] In exemplary embodiments, the blend compositions provide a static dissipative conduit for transport of a flammable fluid.

[0087] In exemplary embodiments, the blend has similar processing properties to PFA and forms an article with product properties similar to PFA while also being static-dissipative, clean, transparent, and/or capable of absorbing metal and metal ions from a fluid stream contacting the polymer.

[0088] In some embodiments, an article includes a uniform blend of the PFA and the sulfonated fluoropolymer throughout the article.

[0089] In other embodiments, the article includes different layers with different amounts of the sulfonated fluoropolymer. The different layers may include one or more layers with no sulfonated fluoropolymer.

[0090] In exemplary embodiments, the article is flexible tubing, a valve, a fitting, a vessel, a surface coating, flexible tubing having a surface coating, a valve having a surface coating, a fitting having a surface coating, or a vessel having a surface coating.

[0091] FIG. 1 shows an article 10 in the form of flexible tubing including a first layer 20, a second layer 30, and a third layer 40. Although the article 10 includes three layers, an article including a static-dissipative polymer blend may alternatively include a single layer, two layers, or more than three layers.

[0092] In some embodiments, the first layer 20 is a substrate and the second layer 30 and the third layer 40 are coatings on the substrate.

[0093] In some embodiments, the first layer 20 is PFA, substantially PFA, or mostly PFA, such as, for example, a first layer 20 that is mostly PFA and may be free of sulfonated fluoropolymer but includes an amount of carbon sufficient to provide for electronic conduction through the first layer 20. In such embodiments, the second layer 30 and the third layer 40 are static dissipative polymer blends of PFA and sulfonated fluoropolymer.

[0094] When the first layer 20, second layer 30, and/or third layer 40 are formed as coatings, they may be formed by any coating method. In some embodiments, the first layer 20, the second layer 30, and/or the third layer 40 are formed as pressed films and/or extruded or co-extruded films.

[0095] Given the higher material cost of the sulfonated fluoropolymer relative to the PFA and the desirability of static-dissipative properties of an article at the surface of the article, a surface layer with a high content of the sulfonated fluoropolymer may be provided at a sufficient thickness for effective charge dissipation by the article. A reduced sulfonated fluoropolymer content in one or more layers below the surface may reduce the materials cost for the article without negatively impacting its ability to dissipate charge.

[0096] Although the static-dissipative compositions are described herein as polymer blends of a sulfonated fluoropolymer and a perfluoroalkoxy alkane, a static-dissipative composition may alternatively be formed as a single functional polymer including monomers of a sulfonated fluoropolymer and monomers of a perfluoroalkoxy alkane. In some such embodiments, the single functional polymer may be a polymer including monomer units of TFE, one or more perfluoroalkylethers, and one or more sulfonated perfluoroethers selected to achieve the static-dissipative and other desirable properties described herein.

TEST METHODS

Melt Flow Rate

[0097] The melt flow rate (MFR) was measured according to ASTM D-3307 at 372°C.

Thermogravimetric Analysis

[0098] The comparative and inventive examples were subjected to a standard 10°C/minute ramp thermogravimetric analyzer (TGA) test under an air or nitrogen atmosphere with a 60 mL/minute flow rate. Weight and temperature data was collected at a rate of 0.50 seconds/point. The reported values in Table 1 are the temperatures at which 1 wt% loss is observed.

Mechanical Properties

[0099] The tensile strength and the ultimate elongation were measured for the comparative and inventive examples at 23 °C by the ISO 37:2011 testing protocol.

[0100] The flex modulus was measured for the comparative and inventive examples according to ASTM D790.

MIT Flex Life

[0101] The MIT flex life was determined by the ASTM D 2176 testing protocol using an 8 mil (0.21 mm) thick test strip of the comparative and inventive examples. The reported values are the average results of five samples.

Static Dissipation

[0102] To evaluate static dissipative properties, the surface conductivity/resistivity of a washed and dried thin film sample was measured using a handheld Model 880 Autoranging Resistance Indicator meter (Electro-Tech Systems, Inc., Glenside, PA). The meter was placed on the film and the order of magnitude of the surface resistivity in ohms was indicated by light-emitting diodes on the meter. Less than 10^6 ohms was considered “conductive” (C), 10^6 to 10^{11} ohms was considered “static dissipative” (SD), and greater than 10^{11} ohms was considered “insulative” (I).

EXAMPLES**COMPARATIVE EXAMPLES**

[0103] Teflon™ PFA 440HPA molding and extrusion resin (The Chemours Company) was used as Comparative Example 1 (CE1) to the inventive blends described herein.

[0104] Teflon™ PFA 940HP Plus molding and extrusion resin (The Chemours Company) was used as Comparative Example 2 (CE2) to the inventive blends described herein.

[0105] Teflon™ PFA 416HP molding and extrusion resin (The Chemours Company) was used as Comparative Example 3 (CE3) to the inventive blends described herein.

[0106] 90 wt% Teflon™ PFA 416HP was blended with 10 wt% Nafion™ R1000 thermoplastic resin to form Comparative Example 4 (CE4).

INVENTIVE EXAMPLES

[0107] 80 wt% Teflon™ PFA 440HPA was blended with 20 wt% Nafion™ R1000 thermoplastic resin (The Chemours Company) to form Inventive Example 1 (IE1).

[0108] 70 wt% Teflon™ PFA 440HPA was blended with 30 wt% Nafion™ R1000 to form Inventive Example 2 (IE2).

[0109] 80 wt% Teflon™ PFA 940HP Plus was blended with 20 wt% Nafion™ R1000 thermoplastic resin to form Inventive Example 3 (IE3).

[0110] 70 wt% Teflon™ PFA 940HP Plus was blended with 30 wt% Nafion™ R1000 to form Inventive Example 4 (IE4).

[0111] 80 wt% Teflon™ PFA 416HP was blended with 20 wt% Nafion™ R1000 thermoplastic resin to form Inventive Example 5 (IE5).

[0112] 70 wt% Teflon™ PFA 416HP was blended with 30 wt% Nafion™ R1000 to form Inventive Example 6 (IE6).

PROCESSING AND BLEND PROPERTIES

[0113] PFA resin pellets and thermoplastic sulfonated fluoropolymer resin in sulfonyl fluoride form at a predetermined weight ratio were added to and tumbled together in a polyethylene bag before being melt extruded through a 1-inch diameter single-screw extruder. The extruded strand was quenched in a water bath before being pelletized using a strand cutter.

[0114] Thin films of compression-molded blend pellets, approximately 4" x 4" in size and 0.01" thick, were formed using a heated platen press. After the thin films were cooled to room temperature, they were exposed to a hydrolysis process of exposure to a solution of 32 wt% potassium hydroxide (KOH) and 8 wt% dimethyl sulfoxide (DMSO) for 90 minutes at a temperature of 93°C to convert the sulfonyl fluoride end groups to carboxylic acid form. The thin films were then washed and dried.

PFA and Blend Properties

[0115] The melt flow rate, the temperature for 1 wt% loss by thermogravimetric analysis, the tensile strength, the ultimate elongation, the flex modulus, the MIT flex life cycle, and the static dissipation were determined for each example. Table 1 shows the results.

TABLE 1: Blend Properties

Property	CE1	IE1	IE2	CE2	IE3	IE4
MFR (g/10 min @ 372°C)	15.6	34.5	41.3	15.7	29.7	37.9
TGA (1 wt% loss) (°C)	496	438	433	481	428	424
Tensile Strength (psi)	4283	3489	3182	5067	4230	3971
Ultimate Elongation (%)	344	344	345	336	344	369
Flex Modulus (psi)	51372	28951	18113	70683	53072	33596
MIT Flex Life (cycles)	12835	26532	25325	101432	79634	38393
Static Dissipation	I	SD	SD	I	SD	SD

[0116] As shown in Table 1, Inventive Examples 1-4 had higher melt flow rates, slightly lower TGA temperatures, slightly lower tensile strengths, similar ultimate elongations, lower flex moduli, and higher MIT flex life values compared to their respective PFA alone. The properties for the blends were adequate, for example, for use as a surface coating, tubing, a valve, a fitting, or a vessel, where PFA might be used but with the added benefit of being static dissipative.

[0117] Teflon™ PFA 416HP, which has a significantly higher melt flow rate than both Teflon™ PFA 440HPA and Teflon™ PFA 940HP Plus, was tested at 100 wt% and in blends at 90 wt%, 80 wt%, and 70 wt% with Nafion™ R1000 thermoplastic resin only for melt flow rate and static dissipation. Melt flow rate increased from 44.9 to 54.5 to 63.5 to 92.2 g/10 min at 372 °C with increasing Nafion™ content (CE3, CE4, IE5, and IE6, respectively). CE3 and CE4 were not static dissipative. IE5 and IE6 were static dissipative.

[0118] All above-mentioned references are hereby incorporated by reference herein.

[0119] While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS

What is claimed is:

1. A composition comprising a polymer blend comprising:
at least 15 wt% of a sulfonated fluoropolymer; and
at least 50 wt% of a perfluoroalkoxy alkane.
2. The composition of claim 1, wherein the polymer blend comprises 15 wt% to about 35 wt% of the sulfonated fluoropolymer and about 65 wt% to 85 wt% of the perfluoroalkoxy alkane.
3. The composition of claim 1 or 2, wherein the sulfonated fluoropolymer and the perfluoroalkoxy alkane are at least 99%, by weight, of the polymer blend.
4. The composition of any of claims 1-3, wherein the polymer blend consists essentially of the sulfonated fluoropolymer and the perfluoroalkoxy alkane.
5. The composition of any of claims 1-4, wherein the polymer blend is free of carbon black.
6. The composition of any of claims 1-5, wherein the sulfonated fluoropolymer is a copolymer of tetrafluoroethylene and a sulfonated perfluoroether.
7. The composition of claim 6, wherein the sulfonated perfluoroether comprises perfluoro-3,6-dioxa-4-methyl-7-octenesulfonyl fluoride.
8. The composition of claim 6, wherein the sulfonated fluoropolymer comprises a perfluorosulfonic acid polymer and the sulfonated perfluoroether comprises a perfluoroether sulfonic acid.
9. The composition of claim 8, wherein the perfluoroether sulfonic acid comprises perfluoro-3,6-dioxa-4-methyl-7-octenesulfonic acid.
10. The composition of any of claims 1-9, wherein the perfluoroalkoxy alkane is a copolymer of tetrafluoroethylene and a perfluoroalkylether.
11. The composition of claim 10, wherein the perfluoroalkylether is selected from the group consisting of perfluoromethyl ether, perfluoroethyl ether, perfluoropropyl ether, and combinations thereof.

12. The composition of any of claims 1-11, wherein the composition is static dissipative.
13. The composition of any of claims 1-12, wherein the composition is transparent.
14. A method of forming a polymer blend, the method comprising:
 - blending a perfluorosulfonyl fluoride polymer with a perfluoroalkoxy alkane to form a polymer composition, wherein the polymer composition comprises at least 15 wt% of the perfluorosulfonyl fluoride polymer and at least 50 wt% of the perfluoroalkoxy alkane; and
 - hydrolyzing the polymer composition to convert the perfluorosulfonyl fluoride polymer to a perfluorosulfonic acid polymer, thereby forming the polymer blend.
15. The method of claim 14, wherein the blending comprises melt extruding the perfluorosulfonyl fluoride polymer with the perfluoroalkoxy alkane.
16. The method of claim 14 or 15, wherein the hydrolyzing the polymer composition comprises exposing the polymer composition to a strong base solution.
17. The method of any of claims 14-16, wherein the polymer composition comprises 15 wt% to about 35 wt% of the perfluorosulfonyl fluoride polymer and about 65 wt% to 85 wt% of the perfluoroalkoxy alkane.
18. The method of any of claims 14-17, wherein the perfluorosulfonyl fluoride polymer and the perfluoroalkoxy alkane are at least 99%, by weight, of the polymer composition.
19. The method of any of claims 14-18, wherein the perfluorosulfonyl fluoride polymer is a copolymer of tetrafluoroethylene and a perfluoroether sulfonyl fluoride.
20. The method of claim 19, wherein the perfluoroether sulfonyl fluoride comprises perfluoro-3,6-dioxa-4-methyl-7-octenesulfonyl fluoride.
21. The method of any of claims 14-20, wherein the perfluoroalkoxy alkane is a copolymer of tetrafluoroethylene and a perfluoroalkylether.

22. The method of claim 21, wherein the perfluoroalkylether is selected from the group consisting of perfluoromethyl ether, perfluoroethyl ether, perfluoropropyl ether, and combinations thereof.
23. A method of transporting a flammable fluid comprising:
 flowing the flammable fluid through a conduit formed by a polymer blend comprising at least 15 wt% of a sulfonated fluoropolymer and at least 50 wt% of a perfluoroalkoxy alkane;
 wherein the polymer blend is static dissipative and transparent.
24. The method of claim 23, wherein the polymer blend comprises 15 wt% to about 35 wt% of the sulfonated fluoropolymer and about 65 wt% to 85 wt% of the perfluoroalkoxy alkane.
25. The method of claim 23 or 24, wherein the sulfonated fluoropolymer and the perfluoroalkoxy alkane are at least 99%, by weight, of the polymer blend.
26. The method of any of claims 23-25, wherein the sulfonated fluoropolymer is a copolymer of tetrafluoroethylene and a sulfonated perfluoroether.
27. The method of claim 26, wherein the sulfonated perfluoroether comprises perfluoro-3,6-dioxo-4-methyl-7-octenesulfonic acid.
28. The method of any of claims 23-28, wherein the perfluoroalkoxy alkane is a copolymer of tetrafluoroethylene and a perfluoroalkylether.
29. The method of claim 28, wherein the perfluoroalkylether is selected from the group consisting of perfluoromethyl ether, perfluoroethyl ether, perfluoropropyl ether, and combinations thereof.
30. An article comprising a polymer blend of at least 15 wt% of a sulfonated fluoropolymer and at least 50 wt% of a perfluoroalkoxy alkane.
31. The article of claim 30, wherein the polymer blend comprises 15 wt% to about 35 wt% of the sulfonated fluoropolymer and about 65 wt% to 85 wt% of the perfluoroalkoxy alkane.
32. The article of claim 30 or 31, wherein the sulfonated fluoropolymer and the perfluoroalkoxy alkane are at least 99%, by weight, of the polymer blend.

33. The article of claim any of claims 30-32, wherein the sulfonated fluoropolymer is a copolymer of tetrafluoroethylene and a sulfonated perfluoroether.
34. The article of claim 33, wherein the sulfonated perfluoroether comprises perfluoro-3,6-dioxo-4-methyl-7-octenesulfonic acid.
35. The article of any of claims 30-34, wherein the perfluoroalkoxy alkane is a copolymer of tetrafluoroethylene and a perfluoroalkylether.
36. The article of claim 35, wherein the perfluoroalkylether is selected from the group consisting of perfluoromethyl ether, perfluoroethyl ether, perfluoropropyl ether, and combinations thereof.
37. The article of any of claims 30-36, wherein the article is an item selected from the group consisting of tubing, a valve, a fitting, and a vessel.
38. The article of any of claims 30-37, wherein the polymer blend is a surface coating.
39. The article of any of claims 30-37, wherein the article comprises a surface layer of the polymer blend on a substrate, the substrate having a lower content of the sulfonated fluoropolymer than the polymer blend.
40. The article of claim 38, wherein the substrate comprises a mixture of perfluoroalkylether and carbon.
41. A composition comprising a copolymer of tetrafluoroethylene, a sulfonated perfluoroether, and a perfluoroalkylether.