compounds and other impurities are always present in fuels, thus the overall tendency of the fuel to generate charge is not predictable and varies at least 100-fold. The magnitude of charge generated also depends on flow velocity. Thus fine filters, such as filter-coalescers can give enormous electrostatic charging because of the huge surface area compared to pipes and fittings. Static charges can also build up rapidly on the surface of fuel in tanks. Because of the unknown level of impurities in a fuel, there is a need to maintain a low fuel surface voltage without adversely affecting the conductivity or surface voltage relaxation time of the fuel.

[0005] In view of the foregoing, embodiments of the disclosure provide additive composition mixtures and methods for synergistically maintaining low surface voltages of distillate fuels. ~~In one aspect, t~~There is provided a synergistic conductivity improver additive composition for a distillate fuel. The ~~said~~ additive composition includes ~~comprising:~~ A) a mixture of (i) alkenyl polysulfone polymer, (ii) C_{16}-C_{24} substituted maleic/polyamine copolymer, (iii) sulfonic acid, and (iv) aromatic solvent; and B) a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound, wherein the additive composition comprises from 30 to 60 wt.% component (A) and from 30 to 60 wt.% component (B) based on a total weight of the additive composition.

[0005a] In one aspect, there is provided a synergistic conductivity improver additive composition for a distillate fuel said additive composition comprising: A) a mixture of (i) alkenyl polysulfone polymer, (ii) C_{16}-C_{24} substituted maleic/polyamine copolymer, (iii) sulfonic acid, and (iv) aromatic solvent; and B) a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound, wherein the additive composition comprises from 30 to 60 wt.% component (A) and from 30 to 60 wt.% component (B) based on a total weight of the additive composition, wherein an amount of (ii) in component (A) ranges from about 8 to about 15 % by weight of a total weight of component (A), and wherein an amount of (v) in component (B) ranges from about 1 to about 10 % by weight of a total weight of component (B).

[0005ba] In another aspect, there is provided a distillate fuel composition comprising a major amount of distillate fuel and a minor conductivity improving amount of the additive composition as defined above.

[0006] ~~In another aspect, t~~There is provided a method for synergistically maintaining an absolute value of surface voltage of a distillate fuel below 1000 voltscomprising providing a distillate fuel and adding to the fuel A) from about 0.25 to about 2.5 mg/L by weight based on a total volume of the fuel composition of a mixture of (i) alkenyl polysulfone polymer, (ii) hydrocarbyl substituted maleic/polyamine copolymer, (iii) sulfonic acid, and (iv) aromatic solvent; and B) from about 0.25 to about 2.5 mg/L by weight based on a total volume of the fuel composition of a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound.

[0006a] In another aspect, there is provided a method for synergistically maintaining an absolute value of surface voltage of a distillate fuel below 1000 voltscomprising providing a distillate fuel and adding to the fuel A) from about 0.25 to about 2.5 mg/L by weight based on a total volume of the fuel composition of a mixture of (i) alkenyl polysulfone polymer, (ii) hydrocarbyl substituted maleic/polyamine copolymer, (iii) sulfonic acid, and (iv) aromatic solvent; and B) from about 0.25 to about 2.5 mg/L by weight based on a total volume of the fuel composition of a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound, wherein an amount of (ii) in component (A) ranges from about 8 to about 15 % by weight of a total weight of component (A), and wherein an amount of (v) in component (B) ranges from about 1 to about 10 % by weight of a total weight of component (B).

[0007] ~~In another aspect, t~~There is provided a method for synergistically maintaining an absolute value of surface voltage of a distillate fuel below 1000 volts comprising: providing a first distillate fuel and adding to the first fuel a fuel additive (A) comprising from about 0.25 to about 2.5 mg/L by weight based on a total volume of the first fuel composition of a mixture of (i) alkenyl polysulfone polymer, (ii) hydrocarbyl substituted maleic/polyamine

copolymer, (iii) sulfonic acid, and (iv) aromatic solvent; providing a second distillate fuel and adding to the second fuel a fuel additive (B) comprising from about 0.25 to about 2.5 mg/L by weight based on a total volume of the second fuel composition of a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound; and mixing the first fuel and the second fuel in a volume ratio of 0.1:1 to 10:1.

[0007a] In another aspect, there is provided a method for synergistically maintaining an absolute value of surface voltage of a distillate fuel below 1000 volts comprising: providing a first distillate fuel and adding to the first fuel a fuel additive (A) comprising from about 0.25 to about 2.5 mg/L by weight based on a total volume of the first fuel composition of a mixture of (i) alkenyl polysulfone polymer, (ii) hydrocarbyl substituted maleic/polyamine copolymer, (iii) sulfonic acid, and (iv) aromatic solvent; providing a second distillate fuel and adding to the second fuel a fuel additive (B) comprising from about 0.25 to about 2.5 mg/L by weight based on a total volume of the second fuel composition of a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound; and mixing the first fuel and the second fuel in a volume ratio of 0.1:1 to 10:1, wherein an amount of (ii) in component (A) ranges from about 8 to about 15 % by weight of a total weight of component (A), and wherein an amount of (v) in component (B) ranges from about 1 to about 10 % by weight of a total weight of component (B).

[0008] Another embodiment of the disclosure provides a distillate fuel composition that includes a major amount of distillate fuel and minor conductivity improving amount of: A) a mixture of (i) alkenyl polysulfone polymer, (ii) C_{16}-C_{24} substituted maleic/polyamine copolymer, (iii) sulfonic acid, and (iv) aromatic solvent; and B) a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound.

[0009] An advantage of the embodiments of the disclosure is that a fuel, particularly an aviation or jet fuel may be maintained at a synergistically low surface voltage while not adversely affecting the conductivity or voltage relaxation time of the fuel. The synergistically

low surface voltage achieved by the presence of two different types of amine polymers from conductivity improving additives was surprising and quite unexpected. In generally, a mixture of polysulfone and amine polymer effectively raises conductivity and increase charge relaxation rates, but may also increase the amount of charge generated when a fuel passes through pipes and filters. The magnitude and direction of the charge (i.e. positive or negative) is determined by pipe material, plastic versus metal, inherent fuel properties, and the additives used. Traditional conductivity additives contain a polysulfone and an epichlorohydrin/diamine polymer. However, a fuel that includes polysulfone and the two different amine polymers described herein provides a lower surface voltage than can be achieved by a conductivity additive or fuel containing only one of the amine polymers. Depending on the formulation of the additive the fuel may have an overall negative or positive net charge.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0010] As used herein, "middle distillate fuel" is understood to mean one or more fuels selected from the group consisting of diesel fuel, biodiesel, biodiesel-derived fuel, synthetic

What is claimed is:

1. A synergistic conductivity improver additive composition for a distillate fuel said additive composition comprising:

A) a mixture of (i) alkenyl polysulfone polymer, (ii) C_{16}-C_{24} substituted maleic/polyamine copolymer, (iii) sulfonic acid, and (iv) aromatic solvent; and

B) a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound,

wherein the additive composition comprises from 30 to 60 wt.% component (A) and from 30 to 60 wt.% component (B) based on a total weight of the additive composition, wherein an amount of (ii) in component (A) ranges from about 8 to about 15 % by weight of a total weight of component (A), and wherein an amount of (v) in component (B) ranges from about 1 to about 10 % by weight of a total weight of component (B).

2. The additive composition of claim 1, wherein an amount of (i) in each of components (A) and (B) ranges from about 10 to about 20 % by weight based on a total weight of each component.

~~3. The additive composition of claim 1, wherein an amount of (ii) in component (A) ranges from about 8 to about 15 % by weight of a total weight of component (A).~~

~~4. The additive composition of claim 1, wherein an amount of (v) in component (B) ranges from about 1 to about 10 % by weight of a total weight of component (B).~~

~~5~~3. The additive composition of claim 1, wherein an amount of (iii) in each of components (A) and (B) ranges from about 5 to about 15 % by weight based on a total weight of each component.

~~6~~4. The additive composition of claim 1, wherein an amount of (iv) in each of components (A) and (B) ranges from about 50 to about 80 % by weight based on a total weight of each component.

~~7~~5. The additive composition of claim 1, wherein component (B) includes from about 1 to about 5 % by weight of (vi) based on a total weight of component (B).

~~8~~6. The additive composition of claim 1, wherein (iv) comprises a mixture of aromatic solvent.

~~97~~. A distillate fuel composition comprising a major amount of distillate fuel and a minor conductivity improving amount of the additive composition of claim 1.

~~108~~. The distillate fuel composition of claim ~~97~~, wherein the additive composition in the fuel ranges from about 0.25 to about 5 mg/L of a total of components (A) and (B) by weight based on a total volume of the fuel composition.

~~119~~. A method for synergistically maintaining an absolute value of surface voltage of a distillate fuel below 1000 volts comprising providing a distillate fuel and adding to the fuel

A) from about 0.25 to about 2.5 mg/L by weight based on a total volume of the fuel composition of a mixture of (i) alkenyl polysulfone polymer, (ii) hydrocarbyl substituted maleic/polyamine copolymer, (iii) sulfonic acid, and (iv) aromatic solvent; and

B) from about 0.25 to about 2.5 mg/L by weight based on a total volume of the fuel composition of a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound, wherein an amount of (ii) in component (A) ranges from about 8 to about 15 % by weight of a total weight of component (A), and wherein an amount of (v) in component (B) ranges from about 1 to about 10 % by weight of a total weight of component (B).

~~1210~~. The method of claim ~~119~~, wherein an amount of (i) in each of components (A) and (B) ranges from about 10 to about 20 % by weight based on a total weight of each component, an amount of (iii) in each of components (A) and (B) ranges from about 5 to about 15 % by weight based on a total weight of each component, and an amount of (iv) in each of components (A) and (B) ranges from about 50 to about 80 % by weight based on a total weight of each component.

~~1311~~. The method of claim ~~119~~, wherein ~~an amount of (ii) in component (A) ranges from about 8 to about 15 % by weight of a total weight of component (A), an amount of (v) in component (B) ranges from about 1 to about 10 % by weight of a total weight of component (B), and~~ an amount of (vi) in component (B) ranges from about 1 to about 5 % by eight of a total weight of component (B).

~~14~~12. A method for synergistically maintaining an absolute value of surface voltage of a distillate fuel below 1000 volts comprising:

providing a first distillate fuel and adding to the first fuel a fuel additive (A) comprising from about 0.25 to about 5 mg/L by weight based on a total volume of the first fuel composition of a mixture of (i) alkenyl polysulfone polymer, (ii) hydrocarbyl substituted maleic/polyamine copolymer, (iii) sulfonic acid, and (iv) aromatic solvent;

providing a second distillate fuel and adding to the second fuel a fuel additive (B) comprising from about 0.25 to about 5 mg/L by weight based on a total volume of the second fuel composition of a mixture of (i) alkenyl polysulfone polymer, (v) polymeric reaction product of a C_8-C_{18} aliphatic amine or diamine with epichlorohydrin; (iii) sulfonic acid, (iv) aromatic solvent; and optionally (vi) a quaternary ammonium compound; and

mixing the first fuel and the second fuel in a volume ratio of 0.1:1 to 10:1,

wherein an amount of (ii) in component (A) ranges from about 8 to about 15 % by weight of a total weight of component (A), and wherein an amount of (v) in component (B) ranges from about 1 to about 10 % by weight of a total weight of component (B).

~~15~~13. The method of claim ~~14~~12, wherein an amount of (i) in each of components (A) and (B) ranges from about 10 to about 20 % by weight based on a total weight of each component, an amount of (iii) in each of components (A) and (B) ranges from about 5 to about 15 % by weight based on a total weight of each component, and an amount of (iv) in each of components (A) and (B) ranges from about 50 to about 80 % by weight based on a total weight of each component.

~~16~~14. The method of claim ~~14~~12, wherein ~~an amount of (ii) in component (A) ranges from about 8 to about 15 % by weight of a total weight of component (A), an amount of (v) in component (B) ranges from about 1 to about 10 % by weight of a total weight of component (B), and~~ an amount of (vi) in component (B) ranges from about 1 to about 5 % by eight of a total weight of component (B).