COMPOSITION INCLUDING AMORPHOUS FLUOROPOLYMER AND FLUOROPLASTIC PARTICLES AND METHODS OF MAKING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to U.S. Provisional Application No. 62/245,334, filed October 23, 2015, the disclosure of which is incorporated by reference in its entirety herein.

BACKGROUND

Fluoroelastomers are known to have excellent mechanical properties, heat resistance, weather resistance, and chemical resistance, for example. Such beneficial properties render fluoroelastomers useful, for example, as O-rings, seals, hoses, skid materials, and coatings (e.g., metal gasket coating for automobiles) that may be exposed to elevated temperatures or corrosive environments. Fluoroelastomers have been found useful in the automotive, chemical processing, semiconductor, aerospace, and petroleum industries, among others.

Fluoroelastomers are typically prepared by combining an amorphous fluoropolymer, sometimes referred to as a fluoroelastomer gum, with one or more curatives, shaping the resulting curable composition into a desired shape, and curing the curable composition. The amorphous fluoropolymer often includes a cure site, which is a functional group incorporated into the amorphous fluoropolymer backbone capable of reacting with a certain curative.

Fluoroplastic particles of various sizes and either having a cure site or not having a cure site have been incorporated into fluoroelastomer matrices to improve one or more properties. See, for example, U.S. Pat. Nos. 7,476,711 (Takahashi et al.); 7,022,773 (Albano et al.); 7,019,083 (Grootaert et al.); 6,756,445 (Irie et al.); 6,734,254 (Worm et al); 6,395,834 (Albano et al.); and U.S. Pat. Appl. Pub. No. 2011/0245402 (Stanga et al.).

SUMMARY

For certain applications, the requirements for mechanical properties and chemical resistance, for example, of elastomers are quite challenging. There is a continued need for improved chemical resistance without sacrificing mechanical properties.

The present disclosure provides a composition that includes an amorphous fluoropolymer having at least one of:

a segment represented by formula I:

$$-CF(Rf)-(CX_2)_n-(CX_2CXR)_m-O-R''_f-O_k-(CXR'CX_2)_p-(CX_2)_q-CF(R'_f)- \quad (I);$$ or "

a terminal segment represented by formula III:

$$R_f-CF(I)-(CX_2)_n-(CX_2CXR)_m-O-R''_f-O_k-(CXR'CX_2)_p-(CX_2)_q-CF(R'_f)- \quad (III),$$

and fluoroplastic particles having a mean particle size of less than 500 nanometers. In Formulas I and III, X is independently selected from F, H, and CI; R_f and R'_f are independently selected from F and a monovalent perfluoroalkyl having 1 to 3 carbon atoms; R is F, or a partially fluorinated or perfluorinated alkyl having 1 to 3 carbon atoms; R''_f is a divalent fluoroalkylene having 1 to 8 carbon atoms or a divalent fluorinated alkylene ether having 1 to 20 carbon atoms and at least one ether linkage; k is 0 or 1; and n, m, p, and q are independently selected from an integer from 0 to 5, with the proviso that when k is 0, n + m is at least 1 and p + q is at least 1.

In one aspect, the present disclosure provides a composition comprising:

fluoroplastic particles having a mean particle size of less than 500 nanometers; and

an amorphous fluoropolymer comprising at least one of:

a segment represented by formula I:

$-CF(R_f)-(CX_2)_n-(CX_2CXR)_m-O-R''_f-O_k-(CXR'CX_2)_p-(CX_2)_q-CF(R'_f)-$ (I); or

a terminal segment represented by formula III:

$R_f-CF(I)-(CX_2)_n-(CX_2CXR)_m-O-R''_f-O_k-(CXR'CX_2)_p-(CX_2)_q-CF(R'_f)-$ (III),

wherein each X is independently F, H, or Cl; R_f and R'_f are each independently F or a monovalent perfluoroalkyl having 1 to 3 carbon atoms; R and R' are each independently F or a partially fluorinated or perfluorinated alkyl having 1 to 3 carbons atoms; R''_f is a divalent fluoroalkylene having 1 to 8 carbon atoms or a divalent fluorinated alkylene ether having 1 to 20 carbon atoms and at least one ether linkage; k is 0 or 1; and n, m, p, and q are each independently an integer from 0 to 5, with the proviso that when k is 0, n + m is at least 1 and p + q is at least 1, wherein the amorphous fluoropolymer is a fluoroelastomer gum..

The present disclosure provides a method of making the composition. The method includes blending a first latex of the fluoroplastic particles and a second latex of the amorphous fluoropolymer. In another aspect, the present disclosure provides a method of making the composition of the disclosure, the method comprising blending a second latex comprising the fluoroplastic particles and a first latex comprising the amorphous fluoropolymer.

In another aspect, the present disclosure provides a cured fluoroelastomer composition that includes a reaction product of a curing reaction of the composition and a peroxide. In another aspect, the present disclosure provides a cured fluoroelastomer comprising a product of a curing reaction of the composition of the disclosure and a peroxide.

In another aspect, the present disclosure provide a shaped article made from the cured fluoroelastomer. In another aspect, the present disclosure provides a shaped article comprising the cured fluoroelastomer of the disclosure.

In this application:

Terms such as "a", "an" and "the" are not intended to refer to only a singular entity, but include the general class of which a specific example may be used for illustration. The terms "a", "an", and "the" are used interchangeably with the term "at least one". Also herein, recitation of "at least one" includes all numbers of one and greater (e.g., at least 2, at least 4, at least 6, at least 8, at least 10, at least 25, at least 50, at least 100, etc.).

The phrase "comprises at least one of followed by a list refers to comprising any one of the items in the list and any combination of two or more items in the list. The phrase "at least one of followed by a list refers to any one of the items in the list or any combination of two or more items in the list.

"Alkyl group" and the prefix "alk-" are inclusive of both straight chain and branched chain groups and of cyclic groups having up to 30 carbons (in some embodiments, up to 20, 15, 12, 10, 8, 7, 6, or 5 carbons) unless otherwise specified. Cyclic groups can be monocyclic or polycyclic and, in some embodiments, have from 3 to 10 ring carbon atoms.

The term "perfluoroalkyl group" includes linear, branched, and/or cyclic alkyl groups in which all C-H bonds are replaced by C-F bonds.

The terms "cure" and "curable" joining polymer chains together by covalent chemical bonds, usually via crosslinking molecules or groups, to form a network polymer. Therefore, in this disclosure the terms "cured" and "crosslinked" may be used interchangeably. A cured or crosslinked polymer is generally characterized by insolubility, but may be swellable in the presence of an appropriate solvent.

"Cure site" refers to functional groups, which may participate in crosslinking.

A "monomer" is a molecule which can undergo polymerization which then forms part of the essential structure of a polymer.