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(54) Title: INORGANIC-ORGANIC NANOCOMPOSITE

(57) Abrégé/Abstract:
The present invention relates to improved nanocomposite compositions and methods for making and using the same. This invention also relates to the use of these inorganic-organic nanocomposite in compositions, for example, coatings, sealants, caulks, adhesives, and as additives for solid polymer-containing compositions.

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(54) Title: INORGANIC-ORGANIC NANOCOMPOSITE

(57) Abstract: The present invention relates to improved nanocomposite compositions and methods for making and using the same. This invention also relates to the use of these inorganic-organic nanocomposite in compositions, for example, coatings, sealants, caulks, adhesives, and as additives for solid polymer-containing compositions.

INORGANIC-ORGANIC NANOCOMPOSITE

FIELD OF THE INVENTION

[0001] The present invention relates generally to improved nanocomposite compositions and methods for making and using the same. More particularly, the present invention relates to inorganic-organic nanocomposites and processes for their preparation. This invention also relates to the use of these inorganic-organic nanocomposite compositions in, for example, coatings, sealants, caulks, adhesives, and plastics.

BACKGROUND OF THE INVENTION

[0002] Inorganic-organic nanocomposites can exhibit mechanical properties superior to those of their separate components. To optimize the performance properties of these materials, it is usually desirable to disperse the inorganic components in the organic matrix on a nanometer length scale. Clays and other layered inorganic materials that can be broken down into nanoscale building blocks are useful for the preparation of inorganic-organic nanocomposites.

[0003] The addition of clay materials to polymers is known in the art, however, incorporating clays into polymers may not provide a desirable improvement in the physical properties, particularly mechanical properties, of the polymer. This may be due, for example, to the lack of affinity between the clay and the polymer at the interface, or the boundary, between the clay and polymer within the material. The affinity between the clay and the polymer may improve the physical properties of the resulting nanocomposite by allowing the clay material to uniformly disperse throughout the polymer. The relatively large surface area of the clay, if uniformly dispersed, may provide more interfaces between the clay and polymer, and may subsequently improve the physical properties, by reducing the mobility of the polymer chains at these interfaces. By contrast, a lack of affinity between the clay and polymer may adversely

affect the strength and uniformity of the composition by having pockets of clay concentrated, rather than uniformly dispersed, throughout the polymer. Affinity between clays and polymers is related to the fact that clays, by nature, are generally hydrophillic whereas polymers are generally hydrophobic.

[0004] Clay minerals are typically comprised of hydrated aluminum silicates that are fine-grained and have a platy habit. The crystalline structure of a typical clay mineral is a multi-layered structure comprised of combinations of layers of SiO_4 tetrahedra that are joined to layers of $AlO(OH)_2$ octahedra. Clay minerals vary based upon the combination of their constituent layers and cations. Isomorphic substitution of the cations of clay mineral, such as Al^{3+} or Fe^{3+} substituting for the Si^{4+} ions in the tetrahedral network, or Al^{3+}, Mg^{2+} or Fe^{2+} substituting for other cations in the octahedral network, typically occurs and may impart a net negative charge on the clay structure. Naturally occurring elements within the gallery of the clay, such as water molecules or sodium or potassium cations, are attracted to the surface of the clay layers due to this net negative charge.

[0005] In order to promote more affinity between the clay and the polymer at the interface and provide a uniform dispersion of the clay within the polymer, the interlayer surface chemistry of the clay may be modified to render the silicate layers less hydrophilic.

[0006] Alkylammonium ions, such as onium salts, are commonly used to prepare clay dispersions for nanocomposite materials. The basic formula for a typical alkylammonium ion is CH_3-$(CH_2)_n$-NH_3^+ where n is from 1 to 18. It is believed that the alkylammonium ions also readily exchange with the naturally occurring cations present between the clay platelets resulting in an intercalated state. Further, it is believed that the alkylammonium ions may increase the space between the clay layers and also may lower

the surface energy of the clay thereby allowing organic species with different polarities to become intercalated between the clay layers.

[0007] A need exists for nanocomposites having improved properties. The invention disclosed herein provides a cost effective and efficient process for the production of novel inorganic-organic nanocomposite compositions that are is especially suitable for use in sealants with the desired characteristics of softness, processability and elasticity are important performance criteria.

SUMMARY OF THE INVENTION

[0008] In accordance with the present invention, an inorganic-organic nanocomposite is provided which comprises at least one inorganic component which is a layered inorganic nanoparticulate and at least one organic component which is a quaternary ammonium organopolysiloxane.

[0009] The novel inorganic-organic nanocomposite of the invention can be used as a filler for a wide variety of polymer resin containing compositions and, in particular, as filler for such compositions intended for application as sealants, coatings and adhesives.

DETAILED DESCRIPTION OF THE INVENTION

[00010] In accordance with the present invention, an inorganic-organic nanocomposite is provided comprising at least one inorganic component which is a layered inorganic nanoparticulate and at least one organic component which is quaternary ammonium organopolysiloxane. When describing the invention, the following terms have the following meanings, unless otherwise indicated.

Definitions

[00011] The term "exfoliation" as used herein describes a process wherein packets of nanoclay platelets separate from one another in a polymer matrix. During exfoliation, platelets at the outermost region of each packet cleave off, exposing more platelets for separation.

[00012] The term "gallery" as used herein describes the space between parallel layers of clay platelets. The gallery spacing changes depending on the nature of the molecule or polymer occupying the space. An interlayer space between individual nanoclay platelets varies, again depending on the type of molecules that occupy the space.

[00013] The term "intercalant" as used herein includes any inorganic or organic compound capable of entering the clay gallery and bonding to its surface.

[00014] The term "intercalate" as used herein designates a clay-chemical complex wherein the clay gallery spacing has increased due to the process of surface modification. Under the proper conditions of temperature and shear, an intercalate is capable of exfoliating in a resin matrix.

[00015] As used herein, the term "intercalation" refers to a process for forming an intercalate.

[00016] The expression "inorganic nanoparticulate" as used herein describes layered inorganic material, e.g., clay, with one or more dimensions, such as length, width or thickness, in the nanometer size range and which is capable of undergoing ion exchange.

[00017] The expression "modified clay" as used herein designates a clay material, e.g., nanoclay, which has been treated with any inorganic or organic compound that is capable of undergoing ion exchange reactions with the cations present at the interlayer surfaces of the clay.

[00018] The term "nanoclay" as used herein describes layered clay materials that possess a unique morphology with one dimension being in the nanometer range. Nanoclays can form chemical complexes with an intercalant that ionically bonds to surfaces in between the layers making up the clay particles. This association of intercalant and clay particles results in a material which is compatible with many different kinds of host resins permitting the clay filler to disperse therein.

[00019] As used herein, the term "nanoparticulate" refers to particle sizes, generally determined by diameter, generally less than about 1000 nm.

[00020] As used herein, the term "platelets" refers to individual layers of the layered material.

[00021] The inorganic nanoparticulate of the inorganic-organic nanocomposite can be natural or synthetic such as smectite clay, and should have certain ion exchange properties as in smectite clays, rectorite, vermiculite, illite, micas and their synthetic analogs, including laponite, synthetic mica-montmorillonite and tetrasilicic mica.

[00022] The nanoparticulates can possess an average maximum lateral dimension (width) in a first embodiment of between about 0.01 μm and about 10 μm, in a second embodiment between about 0.05 μm and about 2 μm, and in a third embodiment between about 0.1 μm and about 1 μm. The average maximum vertical dimension (thickness) of the nanoparticulates can in general vary in a first embodiment between about 0.5 nm and about 10 nm and in a second embodiment between about 1 nm and about 5 nm.

[00023] Useful inorganic nanoparticulate materials of the invention include natural or synthetic phyllosilicates, particularly smectic clays such as montmorillonite, sodium montmorillonite, calcium montmorillonite, magnesium montmorillonite, nontronite, beidellite, volkonskoite, laponite, hectorite, saponite, sauconite, magadite, kenyaite, sobockite, svindordite, stevensite, talc, mica, kaolinite, vermiculite, halloysite, aluminate oxides, or hydrotalcites, micaceous minerals such as illite and mixed layered illite/smectite minerals such as rectorite, tarosovite, ledikite and admixtures of illites with one or more of the clay minerals named above. Any swellable layered material that sufficiently sorbs the organic molecules to increase the interlayer spacing between adjacent phyllosilicate platelets to at least about 5 angstroms, or to at least about 10 angstroms, (when the phyllosilicate is measured dry) can be used in producing the inorganic-organic nanocomposite of the invention.

[00024] The modified inorganic nanoparticulate of the invention is obtained by contacting quantities of layered inorganic particulate possessing exchangeable cation, e.g., Na^{+}, Ca^{2+}, Al^{3+}, Fe^{2+}, Fe^{3+}, and Mg^{2+}, with at least one ammonium-containing organopolysiloxane. The resulting modified particulate is an inorganic-organic nanocomposite possessing intercalated quaternary ammonium organopolysiloxane.

[00025] The ammonium-containing organopolysiloxane must contain at least one ammonium group and can contain two or more ammonium groups. The quaternary ammonium groups can be position at the terminal ends of the organopolysiloxane and/or along the siloxane backbone. One class of useful ammonium-containing organopolysiloxane has the general formula:

$$M_aD_bD'_c$$

wherein "a" is 2, and "b" is equal to or greater than 1 and "c" is zero or positive; M is

$$[R^3_zNR^4]_{3-x-y}R^1_xR^2_ySiO_{1/2}$$

wherein "x" is 0, 1 or 2 and "y" is either 0 or 1, subject to the limitation that x + y is less than or equal to 2, "z" is 2, R^1 and R^2 each independently is a monovalent hydrocarbon group up to 60 carbons; R^3 is selected from the group consisting of H and a monovalent hydrocarbon group up to 60 carbons; R^4 is a monovalent hydrocarbon group up to 60 carbons; D is

$$R^5R^6SiO_{1/2}$$

where R^5 and R^6 each independently is a monovalent hydrocarbon group up to 60 carbon atoms; and D' is

$$R^7R^8SiO_{2/2}$$

where R^7 and R^8 each independently is a monovalent hydrocarbon group containing amine with the general formula:

$$[R^9_aNR^{10}]$$

wherein "a" is 2, R^9 is selected from the group consisting of H and a monovalent hydrocarbon group up to 60 carbons; R^{10} is a monovalent hydrocarbon group up to 60 carbons.

[00026] In another embodiment of the present invention, the ammonium-containing organopolysiloxane is $R^{11}R^{12}R^{13}N$, wherein R^{11}, R^{12}, and R^{13} each independently is an alkoxy silane or a monovalent hydrocarbon group up to 60 carbons. The general formula for the alkoxy silane is

$$[R^{14}O]_{3-x-y}R^{15}_xR^{16}_ySiR^{17}$$

wherein "x" is 0, 1 or 2 and "y" is either 0 or 1, subject to the limitation that x + y is less than or equal to 2; R^{14} is a monovalent hydrocarbon group up to 30 carbons; R^{15} and R^{16} are independently chosen monovalent hydrocarbon groups up to 60 carbons; R^{17} is a

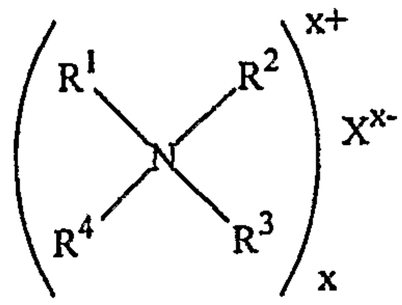
monovalent hydrocarbon group up to 60 carbons. Additional compounds useful for modifying the inorganic component of the present invention are amine compounds or the corresponding ammonium ion with the structure $R^{18}R^{19}R^{20}N$, wherein R^{18}, R^{19}, and R^{20} each independently is an alkyl or alkenyl group of up to 30 carbon atoms, and each independently is an alkyl or alkenyl group of up to 20 carbon atoms in another embodiment, which may be the same or different. In yet another embodiment, the organic molecule is a long chain tertiary amine where R^{18}, R^{19} and R^{20} each independently is a 14 carbon to 20 carbon alkyl or alkenyl.

[00027] The layered inorganic nanoparticulate compositions of the present invention need not be converted to a proton exchange form. Typically, the intercalation of a quaternary ammonium organopolysiloxane into the layered inorganic nanoparticulate material is achieved by cation exchange using solvent and solvent-free processes. In the solvent-based process, the organopolysiloxane ammonium component is placed in a solvent that is inert toward polymerization or coupling reaction. Particularly suitable solvents are water or water-ethanol, water-acetone and like water-polar co-solvent systems. Upon removal of the solvent, the intercalated particulate concentrates are obtained. In the solvent-free process, a high shear blender is usually required to conduct the intercalation reaction. The inorganic-organic nanocomposite may be in a suspension, gel, paste or solid forms.

[00028] A specific class of ammonium-containing organopolysiloxanes are those described in U.S. Patent No. 5,130,396

and can be prepared from known materials including those which are commercially available.

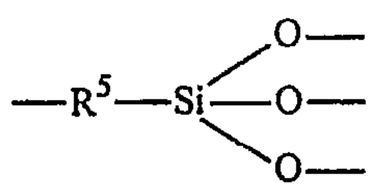
[00029] The ammonium-containing organopolysiloxanes of U.S. Patent No. 5,130,396 is represented by the general formula:



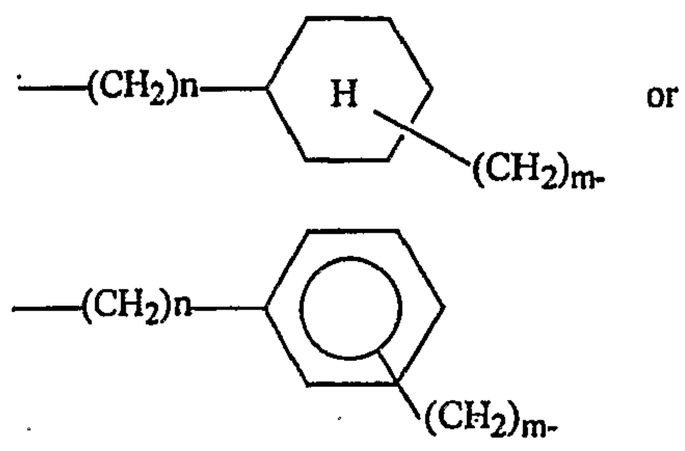
(I)

in which R^1 and R^2 are identical or different and represent a group of the formula:

(II)

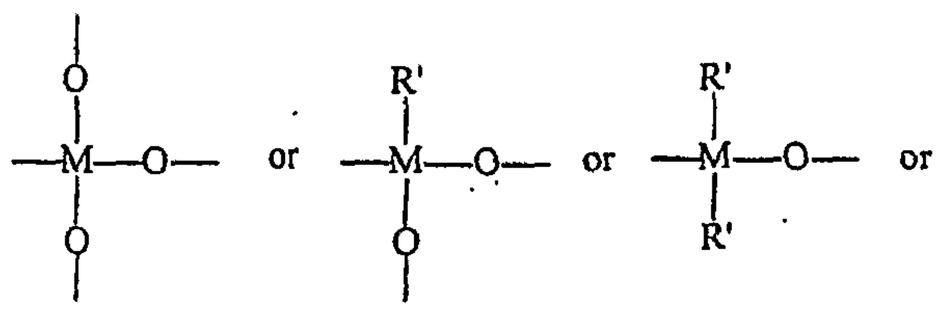


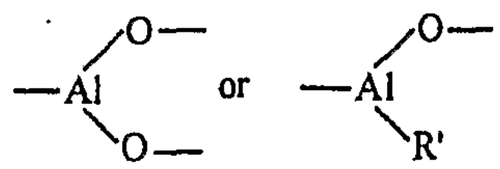
in which the nitrogen atoms in (I) are connected to the silicon atoms in (II) via the R^5 groups and R^5 represents an alkylene group with 1 to 10 carbon atoms, a cycloalkylene group with 5 to 8 atoms or a unit of the general formula:



or

in which n is a number from 1 to 6 and indicates the number of methylene groups in nitrogen position and m is a number from 0 to 6 and the free valences of the oxygen atoms bound to the silicon atom are saturated as in silica skeletons by silicon atoms of other groups of formula (II) and/or with the metal atoms of one or more of the cross-linking binding links





in which M is a silicon, titanium or zirconium atom and R' a linear or branched alkyl group with 1 to 5 carbon atoms and the ratio of the silicon atoms of the groups of formula (II) to the metal atoms in the binding links is 1:0 to and in which R^3 is equal to R^1 or R^2, or hydrogen, or a linear or branched alkyl group of 1 to 20 carbon atoms, a cycloalkyl group of 5 to 8 carbon atoms or is the benzyl group, and R^4 is equal to hydrogen, or a linear or branched alkyl group with 1 to 20 carbon atoms or is a cycloalkyl, benzyl, alkyl, propargyl, chloroethyl, hydroxyethyl, or chloropropyl group consisting of 5 to 8 carbon atoms and X is an anion with the valence of x equal to 1 to 3 and selected from the group of halogenide, hypochlorite, sulfate, hydrogen sulfate, nitrite, nitrate, phosphate, dihydrogen phosphate, hydrogen phosphate, carbonate, hydrogen carbonate, hydroxide, chlorate, perchlorate, chromate, dichromate, cyanide, cyanate, rhodanide, sulfide, hydrogen sulfide, selenide, telluride, borate, metaborate, azide, tetrafluoroborate, tetraphenylborate, hexaflourophosphate, formate, acetate, propionate, oxalate, triflouroacetate, trichloroacetate or benzoate.

[00030] The ammonium-containing organopolysiloxane compounds described herein are macroscopically spherical shaped particles with a diameter of 0.01 to 3.0 mm, a specific surface area of 0 to 1000 m^2 /g, a specific pore volume of 0 to 5.0 ml/g, a bulk density of 50 to 1000 g/l as well as a dry substance basis in relation to volume of 50 to 750 g/l.

[00031] One method of preparing an ammonium-containing organopolysiloxane involves reacting a primary, secondary, or tertiary aminosilane possessing at least one

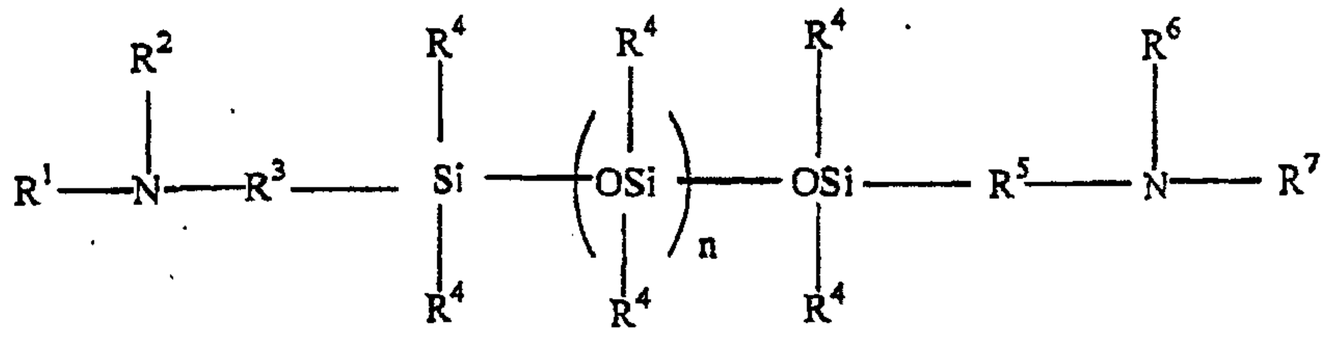
hydrolysable alkoxy group, with water, optionally in the presence of a catalyst, to achieve hydrolysis and subsequent condensation of the silane and produce amine-terminated organopolysilane which is thereafter quaternized with a suitable quarternizing reactant such as a mineral acid and/or alkyl halide to provide the ammonium-containing organopolysiloxane. A method of this type is described in aforesaid U.S. Patent No. 5,130,396. In this connection, U.S. Patent No. 6,730,766,

describes processes for the manufacture of quaternized polysiloxane by the reaction of epoxy-functional polysiloxane.

[00032] In a variation of this method, the primary, secondary or tertiary aminosilane possessing hydrolysable alkoxy group(s) is quarternized prior to the hydrolysis condensation reactions providing the organopolysiloxane. For example, ammonium-containing N-trimethoxysilylpropyl-N, N, N-trimethylammonium chloride, N-trimethoxysilylpropyl-N, N, N-tri-n-butylammonium chloride, and commercially available ammonium-containing trialkoxysilane octadecyldimethyl(3-trimethyloxysilylpropyl) ammonium chloride (available from Gelest, Inc.) following their hydrolysis/condensation will provide ammonium-containing organopolysiloxane for use herein.

[00033] Other suitable tertiary aminosilane useful for preparing ammonium-containing organopolysiloxane include tris(triethoxysilylpropyl)amine, tris(trimethoxysilylpropyl)amine, tris(diethoxymethylsilylpropyl)amine, tris(tripropoxysilylpropyl)amine, tris(ethoxydimethylsilylpropyl)amine, tris(triethoxyphenylsilylpropyl)amine, and the like.

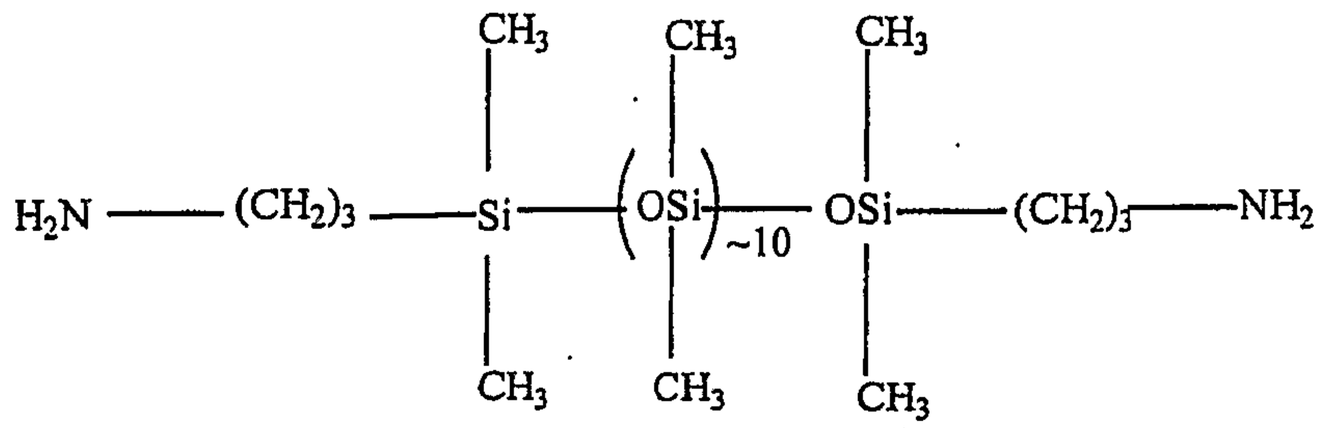
[00034] Still another method for preparing the ammonium-containing organopolysiloxane calls for quarternizing a primary, secondary, or tertiary amine-containing organopolysiloxane with quaternizing reactant. Useful amine-containing organopolysiloxanes include those of the general formula:



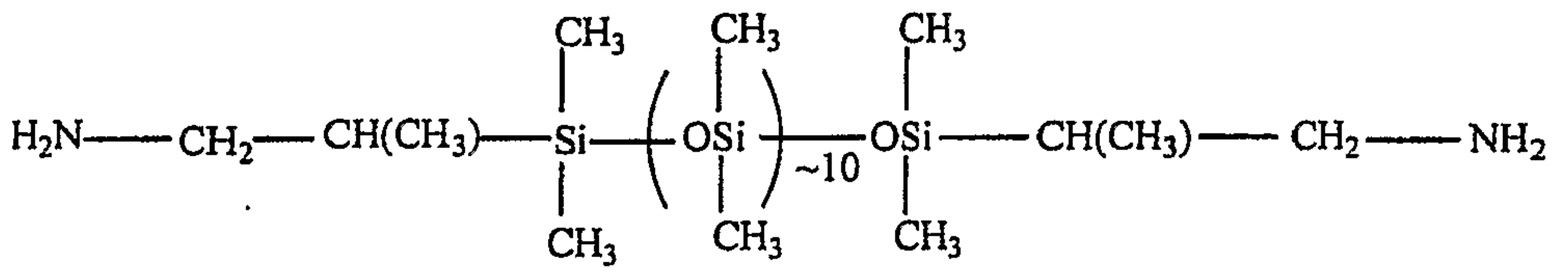
wherein R^1, R^2 R^6, and R^7 each independently is H, hydrocarbyl of up to 30 carbon atoms, e.g., alkyl, cycloalkyl, aryl, alkaryl, aralkyl, etc., or R^1 and R^2 together or R^6 and R^7 together form a divalent bridging group of up to 12 carbon atoms, R^3 and R^5 each independently is a divalent hydrocarbon bridging group of up to 30 carbon atoms, optionally containing one or more oxygen and/or nitrogen atoms in the chain, e.g., straight or branched chain alkylene of from 1 to 8 carbons such as $-CH_2-$, $-CH_2\ CH_2-$, $-CH_2CH_2CH_2-$, $-CH_2-C(CH_3)-CH_2-$, $-CH_2CH_2CH_2\ CH_2-$, etc., each R^4 independently is an alkl group, and n is from 1 to 20 and advantageously is from 6 to 12.

[00035] These and similar amine-containing organopolysiloxanes can be obtained by known and conventional procedures e.g., by reacting an olefinic amine such as allyamine with a polydiorganosiloxane possessing Si-H bonds in the presence of a hydrosilation catalyst, such as, a platinum-containing hydrosilation catalyst as described in U.S. Patent No. 5,026,890 .

[00036] Specific amine-containing organopolysiloxanes that are useful for preparing the ammonium-containing organopolysiloxanes herein include the commercial mixture of



and



[00037] The inorganic-organic nanocomposites of the present invention are useful, *inter alia*, as the sole or partial filler for compositions comprising a solid polymer or mixture/blend of solid polymers.

[00038] Useful solid polymers include epoxy, polycarbonate, silicone, polyester, polyether, polyolefin, natural and synthetic rubber, polyurethane, nylon, polystyrene, polyvinylaromatic, acrylic, acrylate ester, polyamide, polyimide, phenolic, polyvinylhalide, polyphenylene oxide, polyketone, their copolymers and blends thereof. Copolymers include both random and block copolymers. Polyolefin resins include polybutylene, polypropylene and polyethylene, such as low density polyethylene, medium density polyethylene, high density polyethylene, and ethylene copolymers; polyvinylhalide resins include polyvinyl chloride polymers and copolymers and polyvinylidene chloride polymers and copolymers, fluoropolymers; polyvinylaromatic resins include polystyrene polymers and copolymers; acrylate resins include polymers and copolymers of acrylate and methacrylate esters, polyamide resins include nylon 6,

nylon 11, and nylon 12, as well as polyamide copolymers and blends thereof, polyester resins include polyalkylene terephthalates, such as polyethylene terephthalate and polybutylene terephthalate, as well as polyester copolymers; synthetic rubbers include styrene-butadiene and acrylonitrile-butadiene-styrene copolymers and; polyketones include polyetherketones and polyetheretherketones.

[00039] In the resin-filled compositions of the invention, the inorganic-organic nanocomposite is present in an amount, of course, that enhances gas barrier properties therein. In a first embodiment, the inorganic-organic nanocomposite can be present at a level of up to about 90 weight percent, in a second embodiment at a level of up to about 50 weight percent, and third embodiment at a level of up to about 20 weight percent.

[00040] The inorganic-organic nanocomposite of this invention is also advantageously employed as a filler in compositions intended to function as gas barriers, e.g., compositions disclosed and claimed in applicant's co-pending application entitled "ROOM TEMPERATURE CUBABLE ORGANOPOLYSILOXANE COMPOSITION" filed of even date herewith, the contents of which are incorporated herein in their entirety.

[00041] The invention is illustrated by the following non-limiting example:

EXAMPLE 1

[00042] An inorganic-organic nanocomposite in accordance with the invention was prepared by first placing 10 g of amino propyl terminated siloxane ("GAP 10,"siloxane length of 10, from GE Silicones, Waterford, USA) in a 100 ml single-necked round bottomed flask and adding 4 ml of methanol available from Merck. 2.2 ml of concentrated HCl was added very slowly with stirring. The stirring was continued for 10 minutes. 900 ml of water was added to a 2000 ml three-necked round-bottomed flask fitted with condenser and overhead mechanical stirrer. 18 g of Cloisite Na^+ (natural montmorillonite available from Southern Clay Products) clay was added to the water

very slowly with stirring (stirring rate approximately 250 rpm). The ammonium chloride solution (prepared above) was then added very slowly to the clay-water mixture. The mixture was stirred for 1 hour and let stand overnight. The mixture was filtered through a Buckner funnel and the solid obtained was slurried with 800 ml of methanol, stirred for 20 minutes, and then the mixture was filtered. The solid was dried in oven at 80°C for approximately 50 hours.

[00043] While the preferred embodiment of the present invention has been illustrated and described in detail, various modifications of, for example, components, materials and parameters, will become apparent to those skilled in the art, and it is intended to cover in the appended claims all such modifications and changes which come within the scope of this invention.

WHAT IS CLAIMED IS:

1. An inorganic-organic nanocomposite comprising at least one inorganic component which is a layered inorganic nanoparticulate with one or more dimensions of less than 1000nm and which is capable of undergoing ion exchange and at least one organic component which is a quaternary ammonium-containing organopolysiloxane, wherein the quaternary ammonium groups are positioned at the terminal ends of the organopolysiloxane and along the siloxane backbone, and wherein the quaternary ammonium polysiloxane is obtained by hydrosilylating a polydiorganosiloxane possessing Si-H bonds with allylamine in the presence of hydrosilation catalyst to provide amine-containing organopolysiloxane to obtain the quaternary ammonium organopolysiloxane.

2. The inorganic-organic nanocomposite of Claim 1 wherein the layered inorganic nanoparticulate possesses exchangeable cations selected from the group of Na^{+}, Ca^{2+}, Al^{3+}, Fe^{2+}, Fe^{3+}, Mg^{2+}, and mixtures thereof.

3. The inorganic-organic nanocomposite of Claim 1 wherein the layered nanoparticulate is at least one member selected from the group consisting of montmorillonite, sodium montmorillonite, calcium montmorillonite, magnesium montmorillonite, nontronite, beidellite, volkonskoite, laponite, hectorite, saponite, sauconite, magadite, kenyaite, sobockite, svindordite, stevensite, vermiculite, halloysite, aluminate oxides, hydrotalcite, illite, rectorite, tarosovite, ledikitekaolinite and, mixtures thereof.

4. The inorganic-organic nanocomposite of Claim 1 wherein layered inorganic nanoparticulate has an average maximum lateral dimension of between about 0.01 μm and about 10 μm and an average maximum vertical dimension of between about 0.5 nm and about 10 nm.

5. The inorganic-organic nanocomposite of Claim 1 wherein the quaternary ammonium organopolysiloxane is at least one ammonium-containing diorganopolysiloxane having the formula:

$$M_aD_bD'_c$$

wherein "a" is 2, and "b" is equal to or greater than 1 and "c" is zero or positive; M is

$$[R^3_zNR^4]_{3-x-y}R^1_xR^2_ySiO_{1/2}$$

wherein "x" is 0, 1 or 2 and "y" is either 0 or 1, subject to the limitation that x + y is less than or equal to 2, "z" is 2, R^1 and R^2 each independently is a monovalent hydrocarbon group up to 60 carbons; R^3 is selected from the group consisting of H and a monovalent hydrocarbon group up to 60 carbons; R^4 is a monovalent hydrocarbon group up to 60 carbons; D is

$$R^5R^6SiO_{1/2}$$

where R^5 and R^6 each independently is a monovalent hydrocarbon group up to 60 carbon atoms; and D' is

$$R^7R^8SiO_{2/2}$$

where R^7 and R^8 each independently is a monovalent hydrocarbon group containing amine with the general formula:

$$[R^9{}_aNR^{10}]$$

wherein "a" is 2, R^9 is selected from the group consisting of H and a monovalent hydrocarbon group up to 60 carbons; R^{10} is a monovalent hydrocarbon group up to 60 carbons.

6. The inorganic-organic nanocomposite of Claim 5 wherein the quaternary ammonium group is represented by the formula $R^6R^7R^8N^+X^-$ wherein at least one R^6, R^7 and R^8 is an alkoxy silane up to 60 carbon atoms and the remaining are an alkyl or alkenyl group of up to 60 carbon atoms and X is an anion.

7. The inorganic-organic nanocomposite of Claim 1 wherein the quaternary ammonium organopolysiloxane is obtained by reacting an aminosilane possessing at least one hydrolysable group with water under hydrolysis/condensation conditions to provide amine-terminated organopolysiloxane and thereafter quarternizing the amine-terminated organopolysiloxane to provide ammonium organopolysiloxane.

8. The inorganic-organic nanocomposite of Claim 1 wherein the quaternary ammonium organopolysiloxane is obtained by quarternizing an aminosilane possessing at least one hydrolysable alkoxy group(s) prior to hydrolysis/condensation to provide ammonium organopolysiloxane.

9. The inorganic-organic nanocomposite of Claim 1 wherein the quaternary ammonium organopolysiloxane is obtained by hydrosilating hydrogen-terminated organopolysiloxane with allylamine in the presence of hydrosilation catalyst to provide amine terminated organopolysiloxane and thereafter quarternizing the amine-terminated organopolysiloxane to provide ammonium organopolysiloxane.

10. A method of preparing the inorganic-organic nanocomposite of claim 1, comprising the steps of:

a) reacting an aminosilane possessing at least one hydrolyzable alkoxy group with water, optionally, in the presence of catalyst, to provide amine-terminated organopolysiloxane;

b) quaternizing the amine-terminated organopolysiloxane to provide a quarternized organopolysiloxane; and,

c) combining the quaternized organopolysiloxane with layered inorganic nanoparticulate possessing exchangeable cation to provide inorganic-organic nanocomposite.

11. The method of Claim 10 wherein the aminosilane is a primary, secondary or tertiary aminosilane possessing at least one hydrolyzable alkoxy group.

12. The method of Claim 10 wherein the catalyst is selected from the group consisting of organometallic compounds, acids, bases, and mixtures thereof.

13. The method of Claim 10 wherein the amine-terminated organopolysiloxane is quaternized with mineral acid, alkyl halide, or mixture thereof.

14. The inorganic-organic nanocomposite obtained by the method of Claim 10.

15. The inorganic-organic nanocomposite obtained by the method of Claim 11.

16. The inorganic-organic nanocomposite obtained by the method of Claim 12.

17. The inorganic-organic nanocomposite obtained by the method of Claim 13.

18. A composition comprising at least one solid synthetic resin and, as partial or total filler therefor, at least one inorganic-organic nanocomposite of Claim 1.

19. The composition of Claim 18 wherein the resin is at least one selected from the group consisting of epoxy, polycarbonate, silicone, polyester, polyether, polyolefin, natural and synthetic rubber, polyurethane, nylon, polystyrene, polyvinylaromatic, acrylic, acrylate ester polyamide, polyimide, phenolic, polyvinylhalide, polyphenylene oxide, polyketone, their copolymer and blends thereof.

20. The composition of Claim 18 wherein the inorganic-organic nanocomposite is present therein at a level of up to about 90 weight percent.

21. A composition comprising at least one solid synthetic resin and, as partial or total filler therefor, at least one inorganic-organic nanocomposite obtained by the method of Claim 10.

22. The composition of Claim 21 wherein the resin is at least one of epoxy, polycarbonate, silicone, polyester, polyether, polyolefin, natural and synthetic rubber, polyurethane, nylon, polystyrene, polyvinylaromatic, acrylic, acrylate ester polyamide, polyimide, phenolic, polyvinylhalide, polyphenylene oxide, polyketone, their copolymer and blends thereof.

23. The composition of Claim 21 wherein the inorganic-organic nanocomposite is present therein at a level of up to about 90 weight percent.