

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau

(43) International Publication Date  
16 January 2025 (16.01.2025)



(10) International Publication Number  
**WO 2025/015253 A1**

(51) International Patent Classification:

*C09K 8/03* (2006.01) *B01J 20/20* (2006.01)  
*B01J 20/04* (2006.01) *C01D 3/10* (2006.01)

(21) International Application Number:

PCT/US2024/037744

(22) International Filing Date:

12 July 2024 (12.07.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/526,253 12 July 2023 (12.07.2023) US

(71) Applicant: **ALBEMARLE CORPORATION** [US/US];  
4250 Congress Street, Suite 900, Charlotte, North Carolina  
28209 (US).

(72) Inventors: **HAMILTON, Charles Wesley**; 7904 Stone-  
haven Drive, Marvin, North Carolina 28173 (US).  
**NAMJOSHI, Abhijit Anand**; 1626 Gleneagles Bend,  
Zachary, Louisiana 70791 (US).

(74) Agent: **DUNN, Nathan et al.**; 4250 Congress Street, Suite  
900, Charlotte, North Carolina 28209 (US).

(81) Designated States (*unless otherwise indicated, for every  
kind of national protection available*): AE, AG, AL, AM,  
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,  
CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM,  
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,  
HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG,  
KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY,  
MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA,  
NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO,  
RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,  
TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,  
ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every  
kind of regional protection available*): ARIPO (BW, CV,  
GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST,  
SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ,  
RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ,  
DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT,  
LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,  
SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,  
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- as to applicant's entitlement to apply for and be granted a  
patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the  
earlier application (Rule 4.17(iii))

**Published:**

- with international search report (Art. 21(3))

(54) Title: SORBENTS FOR OIL-BASED FLUIDS

(57) Abstract: This invention provides oil-based fluids comprising a halogen-containing sorbent, which sorbent comprises one or more halogens selected from fluorine, chlorine, bromine, and/or iodine, and one or more substrate materials.



WO 2025/015253 A1

## **SORBENTS FOR OIL-BASED FLUIDS**

### **RELATED APPLICATIONS**

[0001] This application claims the benefit of United States Provisional Patent Application Serial No. 63/526,253, filed July 12, 2023, the disclosure of which is incorporated by reference herein in its entirety.

### **TECHNICAL FIELD**

[0002] This invention relates to oil-based fluids comprising a halogen-containing sorbent.

### **BACKGROUND**

[0003] Co-produced water (often called produced water) from oil and gas drilling sometimes contains substances that are environmentally regulated, such as mercury. It is believed that these substances may originate in the hydrocarbons and migrate into the co-produced water. See in this connection Darrell L. Gallup, *Removal of Mercury from Water in the Petroleum Industry*, 21<sup>st</sup> International Petroleum Environmental Conference (IPEC), Houston, TX, October 14-16, 2014; The University of Tulsa, Continuing Education for Science and Engineering. The mercury may be present in multiple forms including elemental mercury, organic mercury compounds, and inorganic mercury compounds. Other substances, including halogenated organic compounds and/or other heavy elements, may also be present in the hydrocarbons and/or produced water.

[0004] It would be desirable to have another method for removing mercury halogenated organic compounds and/or other heavy elements from the hydrocarbons and/or produced water from oil and gas drilling.

### **SUMMARY OF THE INVENTION**

[0005] This invention provides oil-based well fluids comprising a halogenated sorbent. The halogen-containing sorbent can be used alone or in combination with one or more weighting agents, preferably an oil-miscible weighting agent. A benefit provided by this invention is a reduction in the amount of mercury, other heavy metals, and/or halogenated organic compounds in the hydrocarbons and/or produced water from oil and gas drilling. The halogenate sorbents used in the practice of this invention capture mercury in multiple forms

including elemental mercury, organic mercury compounds, and inorganic mercury compounds; these halogenated sorbents can also capture halogenated organic compounds and other heavy elements.

[0006] An embodiment of this invention is an oil-based well fluid comprising a halogen-containing sorbent. The halogen-containing sorbent comprises one or more halogens selected from fluorine, chlorine, bromine, and/or iodine, and one or more substrate materials.

[0007] Another embodiment of this invention is a method of treating a wellbore. The method comprises introducing into the wellbore a fluid containing an oil-based well fluid comprising a halogen-containing sorbent. The halogen-containing sorbent comprises one or more halogens selected from fluorine, chlorine, bromine, and/or iodine, and one or more substrate materials.

[0008] These and other embodiments and features of this invention will be still further apparent from the ensuing description and appended claims.

#### **FURTHER DETAILED DESCRIPTION OF THE INVENTION**

[0009] As used throughout this document, the phrase "halogenated sorbent" is sometimes used to refer to a halogen-containing sorbent used in this invention.

[0010] Throughout this document, the phrase "halogenated organic compounds" refers to halogenated organic compounds that are environmentally regulated.

[0011] Both "ppg" and "lb/gal" are abbreviations for pounds per gallon as used throughout this document.

#### **Halogen-Containing Sorbents**

[0012] Halogen-containing sorbents are typically formed from one or more halogen-containing compounds and one or more substrate materials. Many substrate materials, especially activated carbons, are available or obtainable in a wide range of particle sizes, from nanometer to centimeter.

[0013] Substrate materials include carbonaceous materials and inorganic materials. Suitable carbonaceous materials that can be used as sorbents in the practice of this invention include, for example, without limitation, activated carbon, carbon black, char, and coke. A preferred carbonaceous material is activated carbon, which can be used in many forms including, for example, without limitation, powdered, granular, microspherical, pelleted, or extruded; and high specific surface area.

[0014] Suitable inorganic materials include inorganic oxides such as alumina (amorphous and crystalline), silica, magnesia and titania; natural zeolites such as chabazite, clinoptilolite, and faujasite; synthetic zeolites such as synthetic chabazite, zeolites with high Si:Al ratios (such as ZSM-5, beta zeolites), zeolites with moderate Si:Al ratios (such as Y zeolites, mordenite), zeolites with low Si:Al ratio (such as A zeolites, X zeolites), silica alumina phosphate (SAPO) zeolites, ion exchanged zeolites, uncalcined zeolites with or without organic structure directing agents, aluminosilicates with ordered pore structures (such as MCM-41, MCM-48, SBA-15, HMS, MSU-X), clay minerals such as kaolin, kaolinite, bentonite, and montmorillonite; synthetic clays such as laponite, saponite, sauconite, stevensite, kaolinite, and hectorite; organo-clays such as montmorillonite that has been treated with a trimethyl stearyl ammonium salt, a dimethyl dialkyl (C<sub>14</sub>-C<sub>18</sub>) ammonium salt, a methyl dihydroxy ethyl ammonium salt and a hydrogenated tallow ammonium salt, and aminopropyltriethoxysilane and octadecylamine; bentonite, hectorite, and attapulgite that have been treated with a quaternary ammonium salt; and zeolites that have been treated with N,N,N-trimethyl-1-hexadecanaminium chloride; inorganic hydroxides such as iron hydroxide; mixed metal oxides such as hydrotalcites and metallated double layered clays; diatomaceous earth; cement dust; hydroprocessing catalysts including those on substrates comprising alumina, silica, and/or titania, inorganic carbonates, such as alkali metal carbonates (*e.g.*, sodium carbonate and potassium carbonate) and alkaline earth carbonates (*e.g.*, calcium carbonate); and mixtures of any two or more of the foregoing. Preferred inorganic materials include inorganic oxides, especially silica, natural zeolites, especially chabazite, and clay minerals, especially kaolinite and bentonite; CaCO<sub>3</sub> is also a preferred substrate material.

[0015] The halogen element in the halogen-containing sorbent can be fluorine, chlorine, bromine, iodine, or a mixture of any two or more of these halogens. Bromine and iodine are preferred halogens; bromine is a more preferred halogen. Suitable halogen-containing substances for forming a halogen-containing sorbent include, for example, without limitation, elemental iodine and/or iodine compounds, elemental bromine and/or bromine compounds, elemental chlorine and/or chlorine compounds, elemental fluorine and/or fluorine compounds, and other suitable halogen compounds, as will be known to those skilled in the art. Types of halogen-containing compounds that can be used include hydrohalic acids, alkali metal halides, alkaline earth halides, and ammonium halides. Mixtures of any two or more halogen-containing substances can be used; the mixtures may contain the same or different halogens.

[0016] Hydrohalic acids include hydrogen fluoride, hydrogen chloride, hydrogen bromide, and hydrogen iodide. Bromides and iodides are preferred halides; more preferred are bromides. Alkali metal halides include lithium halides, sodium halides, potassium halides, rubidium halides, and cesium halides; sodium halides and potassium halides are preferred, and include sodium fluoride, sodium chloride, sodium bromide, sodium iodide, potassium fluoride, potassium chloride, potassium bromide, and potassium iodide; more preferred are sodium bromide, potassium bromide, and potassium iodide. Alkaline earth halides include magnesium halides, calcium halides, strontium halides, and barium halides; magnesium halides and calcium halides are preferred, and include magnesium fluoride, magnesium chloride, magnesium bromide, magnesium iodide, calcium fluoride, calcium chloride, calcium bromide, and calcium iodide; more preferred are magnesium bromide and calcium bromide. Ammonium halides include ammonium fluoride, ammonium chloride, ammonium bromide, and ammonium iodide; a preferred ammonium halide is ammonium bromide. More preferred halogen-containing substances include elemental bromine, hydrogen bromide, sodium chloride, sodium bromide, potassium bromide, potassium iodide, and calcium bromide. Bromine-containing compounds are preferred halogen-containing compounds; more preferred are hydrogen bromide and elemental bromine, especially elemental bromine.

[0017] Halogen-containing sorbents can be made from a substrate material and one or more halogen-containing substances, especially for bromine-containing sorbents, as described in U.S. Pat. Nos. 6,953,494 and 9,101,907, and in International Patent Pub. No. WO 2012/071206. In some embodiments, preferred halogen-containing sorbents are bromine-containing sorbents. In some embodiments, preferred halogen-containing sorbents are halogen-containing activated carbons. In other embodiments, preferred halogen-containing activated carbons are chlorine-containing activated carbons, bromine-containing activated carbons, and iodine-containing activated carbons. In preferred embodiments, the halogen-containing sorbents are iodine-containing activated carbons and bromine-containing activated carbons. In more preferred embodiments, the halogen-containing sorbents are bromine-containing activated carbons. Bromine-containing activated carbons are available commercially from Albemarle Corporation.

[0018] In other embodiments, preferred halogen-containing sorbents are chlorine-containing activated carbons and iodine-containing activated carbons. In still other embodiments, preferred halogen-containing sorbents are halogen-containing chabazites, halogen-containing

bentonites, halogen-containing kaolinites, and halogen-containing silicas; more preferred halogen-containing sorbents are iodine-containing chabazites, bromine-containing chabazites, iodine-containing bentonites, bromine-containing bentonites, iodine-containing kaolinites, bromine-containing kaolinites, iodine-containing silicas, and bromine-containing silicas; still more preferred are bromine-containing silica, bromine-containing kaolinite, and bromine-containing bentonites.

[0019] In another embodiment, preferred halogen-containing sorbents include bromine-containing silica, bromine-containing kaolinite, and bromine-containing bentonite.

[0020] The amount of halogen (or halogen content) on the substrate material is typically equivalent to a total bromine content (or calculated as bromine) in the range of about 0.1 wt% to about 50 wt%, preferably equivalent to a total bromine content in the range of about 0.25 wt% to about 40 wt%, more preferably about 0.5 wt% to about 35 wt%, even more preferably about 1 wt% to about 20 wt%, still more preferably about 2 wt% to about 12 wt%, and yet more preferably about 3 wt% to about 8 wt%, based on the total weight of the halogen-containing sorbent.

[0021] As used throughout this document, the phrases "as bromine," "reported as bromine," "calculated as bromine" and analogous phrases for the halogens refer to the amount of halogen, where the numerical value is calculated for bromine, unless otherwise noted. For example, chlorine may be used, but the amount of halogen in the halogen-containing sorbent is stated as the value for bromine.

[0022] Halogen-containing activated carbons suitable for use in processes of this invention can have a wide range of particle sizes and distributions, from nanometer to centimeter; and can be formed from activated carbon forms including, for example, without limitation, powdered, granular, microspherical, pelleted, or extruded; high specific surface area, a variety of unique pore structures; and other features as will be familiar to those skilled in the art.

[0023] The halogen-containing sorbents of this invention are usable alone or in admixture with weighting agents, which are typically oil-miscible weighting agents (OMWA).

[0024] The halogen-containing sorbents are generally miscible with oil-based well fluids. In the practice of this invention, the halogen-containing sorbents are often in a mixture with an oil. Oils with which the halogen-containing sorbents are optionally mixed are oils which usually have a viscosity of about 7 cP or less, and a density typically about 0.7 g/mL to about 0.9 g/mL. The amount of halogen-containing sorbent in the oil can be about 0.1 wt% to about 30 wt%; when more than one halogen-containing sorbent is used, the amount refers to the total

amount of halogen-containing sorbents. Preferred amounts of halogen-containing sorbent in the oil depend on the desired density, and there is typically about 0.1 wt% to about 30 wt% halogen-containing sorbent in a mixture with an oil, more often about 0.1 to about 15 wt%, preferably about 2 wt% to about 10 wt% halogen-containing sorbent in a mixture with an oil. Mixtures of oil and halogen-containing sorbents are often suspensions or slurries. The mixture of oil and the halogen-containing sorbent(s) usually has a viscosity of about 10 cP or less, and a density typically about 0.7 g/mL to about 1.8 g/mL.

[0025] Some of the halogen-containing sorbents have enough high-temperature thermal stability that they can be used in HPHT (high pressure, high temperature) conditions. HPHT conditions are usually defined as a temperature greater than about 250°F (121°C) and a pore pressure greater than about 0.8 psi/ft (15.3 lb/gal).

### **Bromine-Containing Organic Compounds**

[0026] In some embodiments, the oil-based fluid also comprises one or more bromine-containing organic compounds. The bromine-containing organic compounds generally contain two or more bromine atoms and have a bromine content of about 35 wt% or more. Combinations of any two or more of the bromine-containing organic compounds can be used in the practice of this invention, whether the bromine-containing organic compounds are of the same or different types.

[0027] Some of the bromine-containing organic compounds have enough high-temperature thermal stability that they can be used in HPHT (high pressure, high temperature) conditions. HPHT conditions are usually defined as a temperature greater than about 250°F (121°C) and a pore pressure greater than about 0.8 psi/ft (15.3 lb/gal). In addition, the bromine-containing organic compounds, when used in offshore applications, need low-temperature thermal stability because temperatures at the sea floor can be around 5°C.

### **Bromine-Containing Organic Compounds – Group A**

[0028] The first group of bromine-containing organic compounds shares some overall characteristics. In these bromine-containing organic compounds, there are two or more bromine atoms in the molecule, and a bromine content of about 35 wt% or more. The bromine content in these bromine-containing organic compounds is preferably about 35 wt% to about 70 wt%, more preferably about 40 wt% to about 65 wt%, relative to the total weight of the bromine-containing organic compound.

[0029] In some embodiments, bromine-containing organic compound is a bromine-containing monoether compound comprising an oxygen atom and two groups bound thereto, in which a first group contains a terminal alkene moiety or an aromatic-alkyl moiety, wherein the oxygen atom is not bound to an alkenyl carbon atom or an aromatic carbon atom, and a second group selected from a hydrocarbyl group, a trihydrocarbylsilyl group, or a group comprising a terminal alkene moiety or an aromatic-alkyl moiety, in which the oxygen atom is not bound to an alkenyl carbon atom or an aromatic carbon atom. Preferably, the bromine atoms are bound to alkenyl carbon atoms or aromatic carbon atoms. Preferably, there are two to about four bromine atoms per terminal alkene moiety or aromatic-alkyl moiety in the molecule. The bromine-containing monoether compounds typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, and often have densities of about 1.40 g/mL or more.

[0030] When the bromine-containing monoether compound has four or more carbon atoms and a terminal alkene moiety, the monoether compound preferably has four to about fifteen carbon atoms, more preferably five to about twelve carbon atoms, still more preferably five to about ten carbon atoms, in the molecule. The group of the bromine-containing monoether compound that contains the terminal alkene moiety preferably has three to about ten carbon atoms, more preferably three to about eight carbon atoms, still more preferably three to about six carbon atoms, even more preferably three to about four carbon atoms. Suitable terminal alkene moieties include 2-propenyl, 3-butenyl, 4-pentenyl, 5-hexenyl, 6-heptenyl, 7-octenyl, 8-nonenyl, and 9-decenyl; 2-propenyl (sometimes referred to as an allyl group) is a preferred terminal alkene moiety. The bromine atoms are preferably bound to alkenyl carbon atoms. Bromine-containing monoether compounds of this invention comprising a terminal alkene moiety typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, more preferably about 50 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.40 g/mL or more, even more preferably about 1.50 g/mL or more.

[0031] When the bromine-containing monoether compound has eight or more carbon atoms and an aromatic-alkyl moiety, the monoether compound preferably has eight to about twenty carbon atoms, more preferably eight to about fifteen carbon atoms, still more preferably eight to about twelve carbon atoms, in the molecule. The group of the bromine-containing monoether compound that contains the aromatic-alkyl moiety preferably has seven to about fifteen carbon atoms, more preferably seven to about twelve carbon atoms. The aromatic ring

of the aromatic-alkyl moiety may contain one or more hydrocarbyl substituents, which preferably have one to about four carbon atoms. The alkyl portion of the aromatic-alkyl moiety typically contains one to about four carbon atoms and can be straight-chain or branched; preferably, the alkyl portion is straight-chain; more preferably, the alkyl portion has one or two carbon atoms. The bromine atoms are preferably bound to aromatic carbon atoms. Bromine-containing monoether compounds of this invention comprising an aromatic-alkyl moiety typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.40 g/mL or more.

**[0032]** The second group of the bromine-containing monoether compound is selected from a hydrocarbyl group, a trihydrocarbylsilyl group, or a group comprising a terminal alkene moiety having two or more bromine atoms or an aromatic-alkyl moiety having two or more bromine atoms, in which the oxygen atom is not bound to an alkenyl carbon atom or an aromatic carbon atom. When the second group is a group comprising a terminal alkene moiety having two or more bromine atoms or an aromatic-alkyl moiety having two or more bromine atoms, in which the oxygen atom is not bound to an alkenyl carbon atom or an aromatic carbon atom, the groups and preferences are as described above. When the second group is a hydrocarbyl group, the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic; preferably the hydrocarbyl group is a saturated straight chain. Suitable hydrocarbyl groups include methyl, ethyl, n-propyl, 2-propyl, n-butyl, pentyl, cyclopentyl, hexyl, and cyclohexyl; methyl and ethyl are preferred. When the second group is a trihydrocarbylsilyl group, the hydrocarbyl portions of the trihydrocarbylsilyl group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic; preferably the hydrocarbyl portions are saturated straight chains; suitable hydrocarbyl portions include methyl, ethyl, n-propyl, 2-propyl, n-butyl, 2-butyl, pentyl, cyclopentyl, hexyl, and cyclohexyl; methyl and ethyl are preferred, and the three hydrocarbyl portions can be the same or different. Suitable trihydrocarbylsilyl groups include trimethylsilyl, triethylsilyl, diethylmethylsilyl, tri-n-propylsilyl, tri(2-propyl)silyl, tri(n-butyl)silyl, di(n-butyl)methylsilyl, tri(2-butyl)silyl, tripentylsilyl, tricyclopentylsilyl, trihexylsilyl, tricyclohexylsilyl, and cyclohexyldimethylsilyl; preferred trihydrocarbylsilyl groups are trimethylsilyl and triethylsilyl, especially trimethylsilyl.

**[0033]** Suitable bromine-containing monoether compounds comprising a terminal alkene moiety in the practice of this invention include 1,2-dibromo-3-methoxyprop-1-ene, 1,2-dibromo-3-ethoxyprop-1-ene; 1,2-dibromo-3-propoxyprop-1-ene, 1,2-dibromo-3-butoxyprop-

1-ene, 1,2-dibromo-4-methoxybut-1-ene, 1,2-dibromo-4-ethoxybut-1-ene, 1,2-dibromo-4-propoxybut-1-ene, (1E)-1,2-dibromo-3-trimethylsilyloxyprop-1-ene, 1,2-dibromo-3-triethylsilyloxyprop-1-ene, 1,2-dibromo-3-trimethylsilyloxybut-1-ene, and 1,2-dibromo-3-triethylsilyloxybut-1-ene. Preferred monoethers include 1,2-dibromo-3-methoxyprop-1-ene, 1,2-dibromo-3-ethoxyprop-1-ene, and (1E)-1,2-dibromo-3-trimethylsilyloxyprop-1-ene.

**[0034]** Suitable bromine-containing monoether compounds comprising an aromatic-alkyl moiety in the practice of this invention include 1,3-dibromo-5-(methoxymethyl)benzene, 1,3-dibromo-5-(ethoxymethyl)benzene, 1,3-dibromo-5-(n-propoxymethyl)benzene, 3,5-dibromobenzyloxy-trimethylsilane, 3,5-dibromobenzyloxy-triethylsilane, 2-(3,5-dibromophenyl)ethoxy-trimethylsilane, 2-(3,5-dibromophenyl)ethoxy-trimethylsilane, 3,6-dibromo-1-naphthylmethoxy-trimethylsilane, and 3,6-dibromo-1-naphthylmethoxy-triethylsilane. Preferred monoethers include 3,5-dibromobenzyloxy-trimethylsilane.

**[0035]** In some embodiments, the bromine-containing organic compound is a bromine-containing diether compound comprising two oxygen atoms and three groups. One or more of the three groups contains an internal alkene moiety, a terminal alkene moiety, or an aromatic-alkyl moiety, and the three groups are comprised of two end groups, each bound to one of the two oxygen atoms, and a middle group bound to both of the oxygen atoms. Each end group that does not contain an internal alkene moiety, a terminal alkene moiety, or an aromatic-alkyl moiety is a hydrocarbyl group or a trihydrocarbylsilyl group, and when the middle group does not contain an internal alkene moiety, a terminal alkene moiety, or an aromatic-alkyl moiety, the middle group is a hydrocarbylenyl group or a dihydrocarbylsilylenyl group. The oxygen atoms are not bound to an alkenyl carbon atom or an aromatic carbon atom. Preferably, the bromine atoms are bound to alkenyl carbon atoms or aromatic carbon atoms. Preferably there are two to about four bromine atoms per internal alkene moiety, terminal alkene moiety, or aromatic-alkyl moiety in the molecule. The bromine-containing diether compounds typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more.

**[0036]** When an end group of a diether compound is a group comprising a terminal alkene moiety or an aromatic-alkyl moiety, the groups and preferences are as described above. When an end group of a diether compound is a group comprising an internal alkene moiety, the groups and preferences are as described below. When an end group of a diether compound is a hydrocarbyl group or a trihydrocarbylsilyl group, the groups and preferences for both in the

bromine-containing diether compounds are as described above for the second group of the bromine-containing monoether compound.

**[0037]** When the middle group of the diether compound is a hydrocarbylenyl group, the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic; preferably the hydrocarbylenyl group is a saturated straight chain. Suitable hydrocarbylenyl groups include methylenyl, ethylenyl, n-propylenyl, 2-propylenyl, n-butylenyl, pentylenyl, cyclopentylenyl, hexylenyl, and cyclohexylenyl; methylenyl and ethylenyl are preferred.

**[0038]** When the middle group of the diether compound is a dihydrocarbysilylenyl group, the hydrocarbyl portions of the dihydrocarbysilylenyl group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic; preferably the hydrocarbyl portions are saturated straight chains; suitable hydrocarbyl portions include methyl, ethyl, n-propyl, 2-propyl, n-butyl, 2-butyl, pentyl, cyclopentyl, hexyl, and cyclohexyl; methyl and ethyl are preferred, and the two hydrocarbyl portions can be the same or different. Suitable dihydrocarbysilylenyl groups include dimethylsilylenyl, diethylsilylenyl, ethylmethylsilylenyl, di-n-propylsilylenyl, di(2-propyl)silylenyl, di(n-butyl)silylenyl, (n-butyl)methylsilylenyl, di-butyl)silylenyl, dipentylsilylenyl, dicyclopentylsilylenyl, dihexylsilylenyl, dicyclohexylsilylenyl, and cyclohexylmethylsilylenyl; preferred dihydrocarbysilylenyl groups are dimethylsilylenyl and diethylsilylenyl, especially dimethylsilylenyl.

**[0039]** When the bromine-containing diether compound has six or more carbon atoms and an internal alkene moiety, the diether compound preferably has six to about fifteen carbon atoms, more preferably six to about twelve carbon atoms, still more preferably six to about ten carbon atoms in the molecule. The group of the bromine-containing diether compound that contains the internal alkene moiety preferably has four to about eight carbon atoms, more preferably four to about six carbon atoms. Suitable internal alkene moieties include 2-butene, 2-pentene, 2-hexene, 3-hexene, 2-octene 3-octene, and 4-octene; preferred internal alkene moieties include 2-butene. The bromine atoms are preferably bound to alkenyl carbon atoms. Bromine-containing diether compounds of this invention comprising an internal alkene moiety typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more.

**[0040]** When the bromine-containing diether compound has five or more carbon atoms and a terminal alkene moiety, the diether compound preferably has five to about twenty carbon atoms, more preferably five to about fifteen carbon atoms, still more preferably five to about

twelve carbon atoms, in the molecule. The group of the bromine-containing diether compound that contains the terminal alkene moiety preferably has three to about ten carbon atoms, more preferably three to about eight carbon atoms, still more preferably three to about six carbon atoms, even more preferably three to about four carbon atoms. Suitable terminal alkene moieties include 2-propenyl, 3-butenyl, 4-pentenyl, 5-hexenyl, 6-heptenyl, 7-octenyl, 8-nonenyl, and 9-decenyl; 2-propenyl (sometimes referred to as an allyl group) is a preferred terminal alkene moiety. The bromine atoms are preferably bound to alkenyl carbon atoms. Bromine-containing diether compounds of this invention comprising a terminal alkene moiety typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.40 g/mL or more.

**[0041]** When the bromine-containing diether compound has nine or more carbon atoms and an aromatic-alkyl moiety, the diether compound preferably has nine to about thirty carbon atoms, more preferably nine to about twenty-five carbon atoms, still more preferably nine to about twenty carbon atoms, in the molecule. The group of the bromine-containing diether compound that contains the aromatic-alkyl moiety preferably has seven to about fifteen carbon atoms, more preferably seven to about twelve carbon atoms. The aromatic ring of the aromatic-alkyl moiety may contain one or more hydrocarbyl substituents, which preferably have one to about four carbon atoms. The alkyl portion of the aromatic-alkyl moiety typically contains one to about four carbon atoms and can be straight-chain or branched; preferably, the alkyl moiety is straight-chain; more preferably, the alkyl moiety has one or two carbon atoms. The bromine atoms are preferably bound to aromatic carbon atoms. Bromine-containing diether compounds of this invention comprising an aromatic-alkyl moiety typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.40 g/mL or more.

**[0042]** Suitable bromine-containing diether compounds comprising an internal alkene moiety in the practice of this invention include 2,3-dibromo-1,4-dimethoxybut-2-ene, (2E)-2,3-dibromo-1,4-diethoxybut-2-ene, (2E)-2,3-dibromo-1,4-dipropoxybut-2-ene, 2,3-dibromo-1,4-dibutoxybut-2-ene, 2,3-dibromo-1-methoxy-4-(trimethylsiloxy)but-2-ene, 2,3-dibromo-1-ethoxy-4-(trimethylsiloxy)but-2-ene, 2,3-dibromo-1-methoxy-5-(trimethylsiloxy)pent-2-ene, 2,3-dibromo-1-ethoxy-5-(trimethylsiloxy)pent-2-ene, (2E)-2,3-dibromo-1,4-bis(trimethylsiloxy)but-2-ene, 2,3-dibromo-1,4-bis(triethylsiloxy)but-2-ene, 2,3-dibromo-1,5-

bis(trimethylsiloxy)pent-2-ene, and 2,3-dibromo-1,5-bis(triethylsiloxy)pent-2-ene. Preferred bromine-containing diether compounds comprising an internal alkene moiety include (2E)-2,3-dibromo-1,4-diethoxybut-2-ene, (2E)-2,3-dibromo-1,4-dipropoxybut-2-ene, and (2E)-2,3-dibromo-1,4-bis(trimethylsiloxy)but-2-ene.

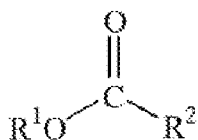
[0043] Suitable bromine-containing diether compounds comprising a terminal alkene moiety in the practice of this invention include (2,3-dibromoprop-2-en-1-yl-oxy)(methoxy)methane, dimethyl(2,3-dibromoprop-2-en-1-yl-oxy)(methoxy)methane, 1-(2,3-dibromoprop-2-en-1-yl-oxy)-2-methoxyethane, bis[(2E)-2,3-dibromoprop-2-en-1-yl-oxy]methane, dimethylbis[(2E)-2,3-dibromoprop-2-en-1-yl-oxy]methane, 1,2-bis(2,3-dibromoprop-2-en-1-yl-oxy)ethane, dimethylbis[(2E)-2,3-dibromoprop-2-en-1-yl-oxy]silane, diethylbis[2,3-dibromoprop-2-en-1-yl-oxy]silane, dimethylbis[3,4-dibromobut-3-en-1-yl-oxy]silane, and diethylbis[3,4-dibromobut-3-en-1-yl-oxy]silane. Preferred silanes include dimethylbis[(2E)-2,3-dibromoprop-2-en-1-yl-oxy]silane.

[0044] Suitable bromine-containing diether compounds comprising an aromatic-alkyl moiety in the practice of this invention include (3,5-dibromobenzyloxy)(methoxy)methane, (3,5-dibromobenzyloxy)(methoxy)-dimethylmethane, 1-(3,5-dibromobenzyloxy)(2-methoxy)-ethane, bis-(3,5-dibromobenzyloxy)methane, bis-(3,5-dibromobenzyloxy)-dimethylmethane, 1,2-bis(3,5-dibromobenzyloxy)-ethane, bis-(3,5-dibromobenzyloxy)-dimethylsilane, bis-(3,5-dibromobenzyloxy)-diethylsilane, bis[2-(3,5-dibromophenyl)ethoxy]-dimethylsilane, bis[2-(3,5-dibromophenyl)ethoxy]-diethylsilane, bis[3,6-dibromo-1-naphthylmethoxy]-dimethylsilane, and bis[3,6-dibromo-1-naphthylmethoxy]-triethylsilane. Preferred bromine-containing diether compounds comprising an aromatic-alkyl moiety include bis-(3,5-dibromobenzyloxy)-dimethylsilane.

### **Bromine-Containing Organic Compounds – Group B**

[0045] The second group of bromine-containing organic compounds shares some overall characteristics. In these bromine-containing organic compounds, there are two or more bromine atoms in the molecule, and a bromine content of 35 wt% or more, preferably about 35 wt% to about 70 wt%, more preferably about 35 wt% to about 65 wt%, relative to the total weight of the bromine-containing organic compound.

[0046] In some embodiments, the bromine-containing organic compound is a bromine-containing monoester which is represented by the formula



where R<sup>1</sup> contains a quaternary carbon atom, a terminal alkene moiety, or an aromatic-alkyl moiety, wherein the oxygen atom adjacent to R<sup>1</sup> is not bound to a quaternary carbon atom, an alkenyl carbon atom or an aromatic carbon atom, and R<sup>2</sup> is a hydrocarbyl group or a bromine-containing hydrocarbyl group. Preferably, the two bromine atoms are bound to carbon atoms adjacent to quaternary carbon atoms, to alkenyl carbon atoms, or to aromatic carbon atoms. When there are more than two bromine atoms in the molecule, it is preferred that two or more bromine atoms are bound to carbon atoms adjacent to quaternary carbon atoms, to alkenyl carbon atoms, or to aromatic carbon atoms. The bromine-containing monoesters typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, more preferably about 45 wt% or more.

[0047] When the bromine-containing monoester has seven or more carbon atoms and R<sup>1</sup> contains a quaternary carbon atom, the monoester preferably has seven to about twenty carbon atoms, more preferably seven to about fifteen carbon atoms, still more preferably seven to about twelve carbon atoms, in the molecule. The group of the bromine-containing monoester that contains the quaternary carbon atom preferably has five to about fifteen carbon atoms, more preferably five to about ten carbon atoms. Suitable quaternary carbon atom moieties include 2,2-dimethyl-1-propyl and 3,3-dimethylbut-1-yl; 2,2-dimethylprop-1-yl (neopentyl) is a preferred quaternary carbon atom moiety. Preferably, the two bromine atoms are bound to carbon atoms adjacent to a quaternary carbon atom. When there are more than two bromine atoms in the molecule, it is preferred that two or more bromine atoms are bound to carbon atoms adjacent to quaternary carbon atoms. Preferably, there are three or more bromine atoms in the molecule; more preferably three or more carbon atoms are bound to carbon atoms adjacent to a quaternary carbon atom. Bromine-containing monoesters of this invention comprising a quaternary carbon atom typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, more preferably about 50 wt% or more, still more preferably about 55 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.45 g/mL or more.

[0048] When the bromine-containing monoester has five or more carbon atoms and R<sup>1</sup> contains a terminal alkene moiety, the monoester preferably has five to about twenty carbon

atoms, more preferably five to about fifteen carbon atoms, more preferably five to about ten carbon atoms, in the molecule. The group of the bromine-containing monoester that contains the terminal alkene moiety preferably has three to about ten carbon atoms, more preferably three to about eight carbon atoms, still more preferably three to about six carbon atoms, even more preferably three to about four carbon atoms. Suitable terminal alkene moieties include 2-propenyl, 3-butenyl, 4-pentenyl, 5-hexenyl, 6-heptenyl, 7-octenyl, 8-nonenyl, and 9-decenyl; 2-propenyl (sometimes referred to as an allyl group) is a preferred terminal alkene moiety. Preferably, the two bromine atoms are bound to alkenyl carbon atoms. When there are more than two bromine atoms in the molecule, it is preferred that two or more bromine atoms are bound to alkenyl carbon atoms. Bromine-containing monoesters of this invention comprising a terminal alkene moiety typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, more preferably about 50 wt% or more, still more preferably about 55 wt% or more.

[0049] When the bromine-containing monoester has nine or more carbon atoms and R<sup>1</sup> contains an aromatic-alkyl moiety, the monoester preferably has nine to about twenty carbon atoms, more preferably nine to about fifteen carbon atoms, in the molecule. The group of the bromine-containing monoester that contains the aromatic-alkyl moiety preferably has seven to about fifteen carbon atoms, more preferably seven to about twelve carbon atoms. The aromatic ring of the aromatic-alkyl moiety may contain one or more hydrocarbyl substituents, which preferably have one to about four carbon atoms. The alkyl portion of the aromatic-alkyl moiety typically contains one to about four carbon atoms and can be straight-chain or branched; preferably, the alkyl portion has one or two carbon atoms. A preferred aromatic-alkyl moiety is a phenylmethyl (benzyl) moiety. Preferably, the two bromine atoms are bound to aromatic carbon atoms. When there are more than two bromine atoms in the molecule, it is preferred that two or more bromine atoms are bound to aromatic carbon atoms. Bromine-containing monoesters of this invention comprising an aromatic-alkyl moiety typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, more preferably about 50 wt% or more, still more preferably about 55 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.45 g/mL or more.

[0050] R<sup>2</sup> is a hydrocarbyl group or a bromine-containing hydrocarbyl group. When R<sup>2</sup> is a hydrocarbyl group, the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic; preferably the hydrocarbyl group is a saturated straight chain or a saturated

branched chain. Suitable hydrocarbyl groups include methyl, ethyl, n-propyl, 2-propyl, 2-methylpropyl, n-butyl, n-pentyl, cyclopentyl, hexyl, and cyclohexyl; methyl, ethyl, n-propyl, 2-propyl, 2-methylpropyl, n-butyl, and n-pentyl are preferred. When  $R^2$  is a bromine-containing hydrocarbyl group, the group contains one or more bromine atoms, and the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic. Preferably, the bromine-containing hydrocarbyl group is a saturated straight chain or a saturated branched chain; preferably, there are one or two bromine atoms in the bromine-containing hydrocarbyl group. Suitable bromine-containing hydrocarbyl groups include bromomethyl, 1-bromoethyl, 2-bromoethyl, 1,2-dibromoethyl, 3-bromo-n-propyl, 2,3-dibromo-n-propyl, 1,3-dibromo-2-propyl, 2-(bromomethyl)propyl, 2-(bromomethyl)-3-bromopropyl, 4-bromo-n-butyl, 3,4-dibromo-n-butyl, 4-bromo-n-pentyl, 4,5-dibromo-n-pentyl, 3-bromocyclopentyl, 3,4-dibromocyclopentyl, 6-bromohexyl, 5,6-dibromohexyl, 4-bromocyclohexyl, 3,4-dibromocyclohexyl and 2,6-dibromocyclohexyl; preferred are bromomethyl and 1-bromoethyl, especially bromomethyl.

**[0051]** Suitable bromine-containing monoesters in which  $R^1$  contains a quaternary carbon atom

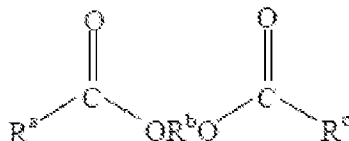
in the practice of this invention include 3-bromo-2,2-bis(bromomethyl)propyl acetate, 3-bromo-2,2-bis(bromomethyl)propyl propionate, 3-bromo-2,2-bis(bromomethyl)propyl butyrate, 3-bromo-2,2-bis(bromomethyl)propyl 2-methylpropanoate, 3-bromo-2,2-bis(bromomethyl)propyl pentanoate, 3-bromo-2,2-bis(bromomethyl)propyl isovalerate, and 3-bromo-2,2-bis(bromomethyl)propyl hexanoate. Preferred bromine-containing monoesters in which  $R^1$  contains a quaternary carbon atom include 3-bromo-2,2-bis(bromomethyl)propyl 2-methylpropanoate.

**[0052]** Suitable bromine-containing monoesters in which  $R^1$  contains a terminal alkene moiety in the practice of this invention include 2,3-dibromoallyl acetate, 2,3-dibromoallyl propionate, and 2,3-dibromoallyl 2-methylpropanoate. Preferred bromine-containing monoesters in which  $R^1$  contains a terminal alkene moiety include 2,3-dibromoallyl 2-methylpropanoate.

**[0053]** Suitable bromine-containing monoesters in which  $R^1$  contains an aromatic-alkyl moiety in the practice of this invention include (3,5-dibromophenyl)methyl acetate, (3,5-dibromophenyl)methyl bromoacetate, (3,5-dibromophenyl)methyl propionate, (3,5-dibromophenyl)methyl butyrate, (3,5-dibromophenyl)methyl 2-methylpropanoate, and (3,5-

dibromophenyl)methyl pentanoate. Preferred bromine-containing monoesters in which R<sup>1</sup> contains an aromatic-alkyl moiety include (3,5-dibromophenyl)methyl pentanoate.

[0054] In some embodiments, the bromine-containing organic compound is a bromine-containing diester which is represented by the formula



wherein R<sup>b</sup> contains a quaternary carbon atom or an internal alkene moiety, wherein the oxygen atoms adjacent to R<sup>b</sup> are not bound to a quaternary carbon atom or an alkenyl carbon atom, and R<sup>a</sup> and R<sup>c</sup> are each, independently, a hydrocarbyl group or a bromine-containing hydrocarbyl group. Preferably, the two bromine atoms are bound to carbon atoms adjacent to quaternary carbon atoms, to alkenyl carbon atoms, or to aromatic carbon atoms. When there are more than two bromine atoms in the molecule, it is preferred that two or more bromine atoms are bound to carbon atoms adjacent to quaternary carbon atoms, to alkenyl carbon atoms, or to aromatic carbon atoms. The bromine-containing diesters typically have a bromine content of about 35 wt% or more, and often have densities of about 1.20 g/mL or more.

[0055] When the bromine-containing diester has nine or more carbon atoms and R<sup>b</sup> contains a quaternary carbon atom, the diester preferably has seven to about thirty carbon atoms, more preferably seven to about twenty-five carbon atoms, still more preferably seven to about twenty carbon atoms, in the molecule. The group of the bromine-containing diester that contains the quaternary carbon atom preferably has five to about ten carbon atoms, more preferably five to about eight carbon atoms. Suitable quaternary carbon atom moieties include 2,2-dimethylpropane-1,3-diyl and 3,3-dimethylpentane-1,3-diyl; 2,2-dimethylpropane-1,3-diyl is a preferred quaternary carbon atom moiety. Preferably, the two bromine atoms are bound to carbon atoms adjacent to a quaternary carbon atom. When there are more than two bromine atoms in the molecule, it is preferred that two or more bromine atoms are bound to carbon atoms adjacent to a quaternary carbon atom. Bromine-containing diesters of this invention comprising a quaternary carbon atom typically have a bromine content of about 35 wt% or more, and often have densities of about 1.20 g/mL or more.

[0056] When the bromine-containing diester has eight or more carbon atoms and R<sup>b</sup> contains an internal alkene moiety, the diester preferably has eight to about thirty carbon atoms, more preferably eight to about twenty-five carbon atoms, still more preferably eight to about twenty

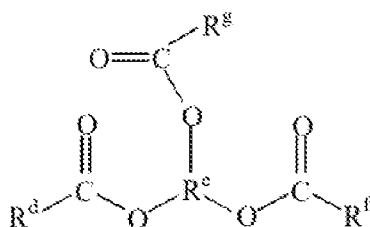
carbon atoms in the molecule. The group of the bromine-containing diester that contains the internal alkene moiety preferably has four to about eight carbon atoms, more preferably four to about six carbon atoms. Suitable internal alkene moieties include 2-butene, 2-pentene, 2-hexene, 3-hexene, 2-octene 3-octene, and 4-octene; preferred internal alkene moieties include 2-butene. Preferably, the two bromine atoms are bound to alkenyl carbon atoms. When there are more than two bromine atoms in the molecule, it is preferred that two or more bromine atoms are bound to alkenyl carbon atoms. Bromine-containing diesters of this invention comprising an internal alkene moiety typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.35 g/mL or more.

[0057]  $R^a$  and  $R^c$  are each, independently, a hydrocarbyl group or a bromine-containing hydrocarbyl group. When  $R^a$  and/or  $R^c$  are a hydrocarbyl group, the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic; preferably the hydrocarbyl group is a saturated straight chain or a saturated branched chain. Suitable hydrocarbyl groups include methyl, ethyl, n-propyl, 2-propyl, 2-methylpropyl, n-butyl, n-pentyl, cyclopentyl, hexyl, and cyclohexyl; methyl, ethyl, n-propyl, 2-propyl, 2-methylpropyl, n-butyl, and n-pentyl are preferred. When  $R^a$  and  $R^c$  are a bromine-containing hydrocarbyl group, the group contains one or more bromine atoms, and the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic. Preferably, the bromine-containing hydrocarbyl group is a saturated straight chain or a saturated branched chain; preferably, there are one or two bromine atoms in the bromine-containing hydrocarbyl group. Suitable bromine-containing hydrocarbyl groups include bromomethyl, 1-bromoethyl, 2-bromoethyl, 1,2-dibromoethyl, 3-bromo-n-propyl, 2,3-dibromo-n-propyl, 1,3-dibromo-2-propyl, 2-(bromomethyl)propyl, 2-(bromomethyl)-3-bromopropyl, 4-bromo-n-butyl, 3,4-dibromo-n-butyl, 4-bromo-n-pentyl, 4,5-dibromo-n-pentyl, 3-bromocyclopentyl, 3,4-dibromocyclopentyl, 6-bromohexyl, 5,6-dibromohexyl, 4-bromocyclohexyl, 3,4-dibromocyclohexyl and 2,6-dibromocyclohexyl; preferred are bromomethyl and 1-bromoethyl, especially bromomethyl.

[0058] Suitable bromine-containing diesters in which  $R^b$  contains a quaternary carbon atom in the practice of this invention include 2,2-bis(bromomethyl) 1,3-diacetoxyp propane, 2,2-bis(bromomethyl)1,3-propanediol-1,3-dipropionate, 2,2-bis(bromomethyl)1,3-propanediol-1,3-di(2-methylpropanoate), 2,2-bis(bromomethyl)1,3-propanediol-1,3-dihexanoate, and 2,2-bis(bromomethyl)1,3-propanediol-1,3-bis-(bromoacetate). Preferred bromine-containing saturated diesters include 2,2-bis(bromomethyl)1,3-propanediol-1,3-dihexanoate.

[0059] Suitable bromine-containing diesters in which  $R^b$  contains an internal alkene moiety in the practice of this invention include (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(propanoate), (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2'-bromobutyrate), (2Z)-but-2-ene-1,4-diyl bis(bromoacetate). Preferred bromine-containing diesters containing an internal alkene moiety include (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(propanoate).

[0060] In some embodiments, the bromine-containing organic compound is a bromine-containing triester which has at least seven carbon atoms and at least two bromine atoms, and is represented by the formula



in which  $R^d$ ,  $R^e$ ,  $R^f$ , and  $R^g$  are each, independently, a hydrocarbyl group or a bromine-containing hydrocarbyl group, and at least one of  $R^d$ ,  $R^e$ ,  $R^f$ , and  $R^g$  is a bromine-containing hydrocarbyl group.

[0061] When  $R^d$ ,  $R^e$ ,  $R^f$ , or  $R^g$  is a hydrocarbyl group, the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic; preferably the hydrocarbyl group is a saturated straight chain or a saturated branched chain. Suitable hydrocarbyl groups include methyl, ethyl, n-propyl, 2-propyl, 2-methylpropyl, n-butyl, n-pentyl, cyclopentyl, hexyl, and cyclohexyl; methyl, ethyl, n-propyl, 2-propyl, 2-methylpropyl, n-butyl, and n-pentyl are preferred. When  $R^d$ ,  $R^e$ ,  $R^f$ , or  $R^g$  is a bromine-containing hydrocarbyl group, the group contains one or more bromine atoms, and the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic. Preferably, the bromine-containing hydrocarbyl group is a saturated straight chain or a saturated branched chain; preferably, there are one or two bromine atoms in the bromine-containing hydrocarbyl group. Suitable bromine-containing hydrocarbyl groups include bromomethyl, 1-bromoethyl, 2-bromoethyl, 1,2-dibromoethyl, 3-bromo-n-propyl, 2,3-dibromo-n-propyl, 1,3-dibromo-2-propyl, 2-(bromomethyl)propyl, 2-(bromomethyl)-3-bromopropyl, 4-bromo-n-butyl, 3,4-dibromo-n-butyl, 4-bromo-n-pentyl, 4,5-dibromo-n-pentyl, 3-bromocyclopentyl, 3,4-dibromocyclopentyl, 6-bromohexyl, 5,6-dibromohexyl, 4-bromocyclohexyl, 3,4-dibromocyclohexyl and 2,6-dibromocyclohexyl; preferred are bromomethyl and 1-bromoethyl, especially bromomethyl.

[0062] Suitable bromine-containing triesters in the practice of this invention include 1,2,3-propanetriyl tris(bromoacetate) and 1,2,3-propanetriyl tris(3-bromopropanoate). Preferred bromine-containing triesters include 1,2,3-propanetriyl tris(bromoacetate).

### **Bromine-Containing Organic Compounds – Group C**

[0063] The third group of bromine-containing organic compounds shares some overall characteristics. In these bromine-containing organic compounds, there are two or more bromine atoms in the molecule, and a bromine content of about 35 wt% or more. The bromine content in these bromine-containing organic compounds is preferably about 35 wt% to about 70 wt%, more preferably about 40 wt% to about 65 wt%, relative to the total weight of the bromine-containing organic compound.

[0064] In some embodiments, the bromine-containing organic compound is a bromine-containing saturated cyclic diether comprising two or more bromine atoms, and a saturated ring comprising two oxygen atoms and three or more carbon atoms, the saturated ring having one or more hydrocarbyl substituents, each bound to a carbon atom of the saturated ring, wherein each bromine atom is bound to a hydrocarbyl substituent. The bromine-containing saturated cyclic diether has four or more carbon atoms, preferably four to about fifteen carbon atoms, more preferably four to about twelve carbon atoms, still more preferably five to about ten carbon atoms, in the molecule.

[0065] The saturated ring of the cyclic diether can be a five-membered, six-membered, seven-membered ring, or a larger ring; five-membered and six-membered rings are preferred, and the saturated ring is often a 1,2-dioxolane, 1,3-dioxolane, 1,4-dioxolane, 1,2-dioxane, 1,3-dioxane, or 1,4-dioxane ring; preferred is a 1.3 dioxane ring.

[0066] There are one or more hydrocarbyl substituents on the saturated ring; when there is more than one hydrocarbyl substituent, they can be on the same or different carbon atoms of the saturated ring. Preferably, the saturated ring has one to about three hydrocarbyl substituents. The hydrocarbyl substituents on the saturated ring can be saturated or unsaturated, straight chain, branched, or aromatic; preferably the hydrocarbyl portions are saturated straight chains. Suitable hydrocarbyl portions include methyl, ethyl, ethenyl, n-propyl, 2-propyl, n-butyl, pentyl, cyclopentyl, hexyl, cyclohexyl, and phenyl; methyl and phenyl are preferred.

[0067] The bromine atoms are located on the hydrocarbyl substituent(s) of the saturated ring. When there is more than one hydrocarbyl substituent on the saturated ring, the bromine atoms can be on the same or different hydrocarbyl substituent; preferably, the bromine atoms are on

different hydrocarbyl substituents. The bromine atoms are in positions on the hydrocarbyl substituent which do not have beta hydrogen atoms.

[0068] Preferably, there are two to about four, more preferably, two to about three, bromine atoms in the bromine-containing saturated cyclic diethers. Bromine-containing saturated cyclic diethers typically have a bromine content of about 40 wt% or more, preferably about 45 wt% or more, and often have densities of about 1.50 g/mL or more.

[0069] Suitable cyclic diethers in the practice of this invention include 4,4-bis(2-bromoethyl)-1,2-dioxolane, 4,5-bis(3-bromo-n-propyl)-1,3-dioxolane, 5,5-bis(bromomethyl)-1,2-dioxane, 5,5-bis(bromomethyl)-2-ethyl-1,3-dioxane, and 2-methyl-5-(1,2-dibromoethyl)-1,4-dioxane. Preferred cyclic diethers include 5,5-bis(bromomethyl)-1,2-dioxane and 5,5-bis(bromomethyl)-2-ethyl-1,3-dioxane, especially 5,5-bis(bromomethyl)-2-ethyl-1,3-dioxane.

[0070] In some embodiments, the bromine-containing organic compound is a bromine-containing aromatic diether comprising one phenyl ring having two or three bromine atoms bound to the phenyl ring and at least one oxygen-containing group bound to the phenyl ring via an oxygen atom, with the proviso that when there is only one oxygen-containing group, the oxygen-containing group is an alkoxyether group. There are preferably eight to about twenty carbon atoms, more preferably eight to about sixteen carbon atoms, in the bromine-containing aromatic diether molecule. When there are two bromine atoms on the phenyl ring, the bromine atoms are preferably ortho or para relative to each other. The bromine-containing aromatic diethers typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, more preferably about 45 wt% or more.

[0071] When there is only one oxygen-containing group in the bromine-containing aromatic diether, In the alkoxyether groups, the hydrocarbyl portions of the groups are saturated. The alkoxyether groups have two to about eight carbon atoms, preferably three to about six carbon atoms, more preferably two to about three oxygen atoms. More preferably, the alkoxyether group containing two or more oxygen atoms has an ethylene unit between each pair of oxygen atoms, and the terminal group is preferably methyl or ethyl. Preferred alkoxyether groups include 2-methoxyethoxy and 2-ethoxyethoxy. When there is only one oxygen-containing group in the brominated benzene molecule, at least one bromine atom is preferably adjacent (*ortho*) to the group containing two or more oxygen atoms; in some preferred embodiments, two bromine atoms are adjacent to the alkoxyether group.

[0072] When there is more than one oxygen-containing group on the phenyl ring of the bromine-containing aromatic diether, one of the oxygen-containing groups is a hydrocarbyloxy

group. More preferably, the hydrocarbyloxy group is an alkoxy group having one to about four carbon atoms, preferably one or two carbon atoms. Preferred hydrocarbyloxy groups include methoxy and ethoxy.

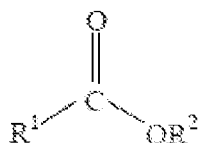
[0073] When there are two oxygen-containing groups on the phenyl ring of the brominated benzenes, preferably one of the oxygen-containing groups is an alkoxyether group and the other oxygen-containing group is a hydrocarbyloxy group; preferences for alkoxyether groups and hydrocarbyloxy groups are as described above. More preferably, there are two bromine atoms on the phenyl ring when there are two oxygen-containing groups on the phenyl ring of the bromine-containing aromatic diether.

[0074] Suitable bromine-containing aromatic diethers in the practice of this invention include 1,3-dibromo-4-(2-ethoxy)ethoxybenzene, 1,2-dibromo-4-butoxy-5-ethoxybenzene, 2,4-dibromo-5-methoxy-1-[(2-ethoxy)ethoxy]benzene, 2,4-dibromo-5-ethoxy-1-[(2-ethoxy)ethoxy]benzene, 2,4-dibromo-1-[(2-ethoxy)ethoxy]benzene, 2,6-dibromo-1-[(2-ethoxy)ethoxy]benzene; preferred bromine-containing aromatic diethers include 1,3-dibromo-4-(2-ethoxy)ethoxybenzene, and 1,2-dibromo-4-butoxy-5-ethoxybenzene.

#### Bromine-Containing Organic Compounds – Group D

[0075] The fourth group of bromine-containing organic compounds comprises bromine-containing esters which have two or more bromine atoms in the molecule, and a bromine content of about 35 wt% or more.

[0076] In some embodiments, the bromine-containing organic compound is a bromine-containing monoester represented by the formula



where R<sup>1</sup> contains a phenyl ring having two or more bromine atoms bound thereto and R<sup>2</sup> is a saturated hydrocarbyl group or an oxygen-containing group which is an ether group or a polyether group. The bromine-containing monoester preferably has eight to about thirty carbon atoms, more preferably eight to about twenty-five carbon atoms, in the molecule. The phenyl ring may contain one or more hydrocarbyl substituents, which preferably have one to about four carbon atoms. There are typically six to about fifteen carbon atoms, preferably six to

about ten carbon atoms, in  $R^1$ . Preferably, the phenyl ring contains two to about four bromine atoms, more preferably three to about four bromine atoms.

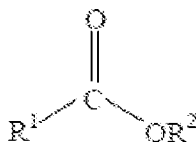
[0077] When  $R^2$  of the bromine-containing monoester is a saturated hydrocarbyl group, the group can be straight chain, branched, or cyclic; preferably the hydrocarbyl group is a saturated straight or branched chain, more preferably a saturated branched chain.  $R^2$  has one to about twenty carbon atoms, more preferably about four to about twenty carbon atoms, still more preferably about four to about fifteen carbon atoms. Suitable hydrocarbyl groups include methyl, ethyl, n-propyl, 2-propyl, n-butyl, 2-butyl, pentyl, 3-ethylpentyl, cyclopentyl, 3-methylcyclopentyl, hexyl, 2-ethylhexyl, cyclohexyl, cyclohexyl, heptyl, octyl, 4-butyloctyl, nonyl, 4-propylnonyl, decyl, and 4-n-butyldecyl; preferred saturated hydrocarbyl groups include 2-ethylhexyl, 2-butyloctyl, and 4-butyloctyl.

[0078] When  $R^2$  of the bromine-containing monoester is an ether group or a polyether group, the hydrocarbyl portions of the groups are saturated. The oxygen-containing groups have two to about ten carbon atoms, preferably three to about eight carbon atoms. The polyether groups have two to about six oxygen atoms, preferably two to about five oxygen atoms. More preferably, the polyether groups containing two or more oxygen atoms have an ethylene unit between each pair of oxygen atoms, and the terminal group is preferably methyl or ethyl. Preferred oxygen-containing groups include 2-methoxyethyl, 2-ethoxyethyl, 3,6-dioxaoctyl, and 4,7,10-trioxaundecyl; 3,6-dioxaoctyl is a preferred oxygen-containing group.

[0079] Bromine-containing monoesters of this invention typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, more preferably about 50 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.40 g/mL or more.

[0080] Suitable bromine-containing monoesters in the practice of this invention include 4-butyloctyl 2,3,4,5-tetrabromobenzoate.

[0081] In some embodiments, the bromine-containing organic compound is mixture of bromine-containing esters comprising a bromine-containing monoester as in a) above, represented by the formula

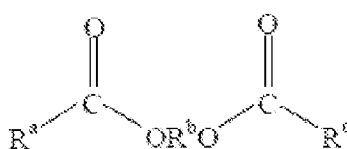


and a bromine-containing diester containing a phenyl ring having two or more bromine atoms bound thereto and having two  $-(C=O)OR^3$  moieties bound to the phenyl ring where each  $R^3$  is a saturated hydrocarbyl group or an oxygen-containing group which is an ether group or a polyether group. Characteristics and preferences for the monoester are as described above.

**[0082]** The bromine-containing diester in the mixture has two  $-(C=O)OR^3$  moieties bound to the phenyl ring, and each  $R^3$  is a saturated hydrocarbyl group or an oxygen-containing group which is an ether group or a polyether group; the two  $R^3$  groups in the molecule can be the same or different. Groups and preferences for  $R^3$  are the same as described for  $R^2$  above. The bromine-containing diester preferably has ten to about forty carbon atoms, more preferably ten to about thirty-five carbon atoms, in the molecule. The phenyl ring may contain one or more hydrocarbyl substituents, which preferably have one to about four carbon atoms. Preferably, the phenyl ring contains two to about four bromine atoms, more preferably three to about four bromine atoms. Mixtures comprising bromine-containing esters of this invention often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.40 g/mL or more.

**[0083]** Suitable mixtures of bromine-containing esters in the practice of this invention include a mixture comprising 2-butyloctyl 2,3,4,5-tetrabromobenzoate and di(2-butyloctyl) 3,4,5,6-tetrabromophthalate.

**[0084]** In some embodiments, the bromine-containing organic compound is a mixture of bromine-containing diesters, each having eight or more carbon atoms and each represented by the formula



where  $R^b$  contains an internal alkene moiety, wherein the oxygen atoms adjacent to  $R^b$  are not bound to an alkenyl carbon atom, and  $R^a$  and  $R^c$  are each, independently, a hydrocarbyl group or a chlorine-containing hydrocarbyl group, with the proviso that in one or more of the bromine-containing diesters in the mixture at least one of  $R^a$  and  $R^c$  is a chlorine-containing hydrocarbyl group.

**[0085]** Each of the diesters in the mixtures of bromine-containing diesters in which  $R^b$  contains an internal alkene moiety preferably has eight to about thirty carbon atoms, more preferably eight to about twenty-five carbon atoms, still more preferably eight to about twenty

carbon atoms in the molecule.  $R^b$  preferably has four to about eight carbon atoms, more preferably four to about six carbon atoms. Suitable internal alkene moieties include 2-butene, 2-pentene, 2-hexene, 3-hexene, 2-octene 3-octene, and 4-octene; preferred internal alkene moieties include 2-butene. The bromine atoms are preferably bound to alkenyl carbon atoms.

[0086]  $R^a$  and  $R^c$  are each, independently, a hydrocarbyl group or a chlorine-containing hydrocarbyl group. When  $R^a$  and/or  $R^c$  is a hydrocarbyl group, the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic; preferably the hydrocarbyl group is a saturated straight chain or a saturated branched chain. Suitable hydrocarbyl groups include methyl, ethyl, n-propyl, 2-propyl, 2-methylpropyl, n-butyl, n-pentyl, cyclopentyl, hexyl, and cyclohexyl. Methyl, ethyl, n-propyl, 2-propyl, 2-methylpropyl, n-butyl, and n-pentyl are preferred hydrocarbyl groups.

[0087] When  $R^a$  and/or  $R^c$  is a chlorine-containing hydrocarbyl group, the group contains one or more chlorine atoms, and the group can be saturated or unsaturated, straight chain, branched, cyclic, or aromatic. Preferably, the chlorine-containing hydrocarbyl group is a saturated straight chain or a saturated branched chain. The number of chlorine atoms in the chlorine-containing hydrocarbyl group is from one to perchlorination. Suitable chlorine-containing hydrocarbyl groups include chloromethyl, trichloromethyl, 1-chloroethyl, 2-chloroethyl, 1,2-dichloroethyl, 3-chloro-n-propyl, 3,3,3-trichloro-n-propyl, 2,3-dichloro-n-propyl, 1,3-dichloro-2-propyl, 2-(chloromethyl)propyl, 2-(trichloromethyl)propyl, 2-(chloromethyl)-3-chloropropyl, 4-chloro-n-butyl, 4,4,4-trichloro-n-butyl, 3,4-dichloro-n-butyl, 4-chloro-n-pentyl, 4,5-dichloro-n-pentyl, 5,5,5-trichloro-n-pentyl, 3-chlorocyclopentyl, 3,4-dichlorocyclopentyl, 6-chlorohexyl, 6,6,6-trichlorohexyl, 5,6-dichlorohexyl, 4-chlorocyclohexyl; 3,4-dichlorocyclohexyl and 2,6-dichlorocyclohexyl; preferred are trichloromethyl and 1,2-dichloroethyl, especially trichloromethyl.

[0088] Mixtures of bromine-containing diesters of this invention often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.40 g/mL or more.

[0089] Suitable mixtures of bromine-containing diesters in the practice of this invention include a mixture comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(trichloroacetate), and (2E)-2,3-dibromo-4-[(trichloroacetyl)oxy]but-2-en-1-yl 2-methylpropanoate.

[0090] In some embodiments, the bromine-containing organic compound is a mixture of bromine-containing diesters comprising bis (2-ethylhexyl) adipate, 2,2-

bis(bromomethyl)propane-1,3-diyl bis[1-O-hexanedionyl(6-*O*-2-ethylhexanoate)], 3-bromo-2-[(hexanoyl)oxy]methyl}-2-(bromomethyl)propyl [1-O-hexanedionyl(6-*O*-2-ethylhexanoate)], and 3,3,14,14-tetra(bromomethyl)-1,5,12,16-tetraoxacyclodocosane-6,11,17,22-tetrone.

### **Bromine-Containing Organic Compounds – Group E**

[0091] The fifth group of bromine-containing organic compounds shares some overall characteristics. All of the bromine-containing organic compounds of this group are bromine-containing hydrocarbons having two or more bromine atoms in the molecule, and a bromine content of about 45 wt% or more, often about 50 wt% or more, preferably about 55 wt% or more, still more preferably about 60 wt% or more, relative to the total weight of the bromine-containing organic compound.

[0092] In some embodiments, the bromine-containing organic compound is a bromine-containing terminal alkene. The bromine-containing terminal alkene has three or more carbon atoms, preferably three to about six carbon atoms in the molecule. Suitable terminal alkenes include 1-propene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, and 1-decene; 2-propene is a preferred terminal alkene. Preferably, the two bromine atoms are bound to alkenyl carbon atoms. When there are more than two bromine atoms in the molecule, it is preferred that two or more bromine atoms are bound to alkenyl carbon atoms. Bromine-containing terminal alkenes of this invention typically have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, more preferably about 50 wt% or more, still more preferably about 55 wt% or more, and often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.40 g/mL or more, still more preferably about 1.50 g/mL or more. A preferred bromine-containing terminal alkene in the practice of this invention is 1,2-dibromo-1-hexene.

[0093] In some embodiments, the bromine-containing organic compound is a bromine-containing internal alkene. The bromine-containing internal alkene has four or more carbon atoms, preferably four to about eight carbon atoms in the molecule. Suitable internal alkene moieties include 2-butene, 2-pentene, 2-hexene, 3-hexene, 2,4-hexadiene, 2-octene 3-octene, and 4-octene; preferred internal alkene moieties include 2-butene and 2,4-hexadiene. Preferably, the two bromine atoms are bound to alkenyl carbon atoms. When there are more than two bromine atoms in the molecule, it is preferred that two or more bromine atoms are bound to alkenyl carbon atoms. Bromine-containing internal alkenes of this invention typically

have a bromine content of about 35 wt% or more, preferably about 40 wt% or more, more preferably about 50 wt% or more, still more preferably about 55 wt% or more, even more preferably about 60 wt% or more. The bromine content is preferably in the range of about 35 wt% to about 85 wt%, preferably about 40 wt% to about 80 wt%. The bromine-containing internal alkenes often have densities of about 1.20 g/mL or more, preferably about 1.30 g/mL or more, more preferably about 1.40 g/mL or more, still more preferably about 1.50 g/mL or more. Preferred bromine-containing internal alkenes in the practice of this invention include 2,3-dibromo-2-butene and 2,3,4,5-tetrabromo-2,4-hexadiene.

[0094] In some embodiments, the bromine-containing organic compound is a tribromocumene mixture comprising 2,4,5-tribromocumene and one or more unsubstituted tribromobenzenes. The 2,4,5-tribromocumene is about 70 wt% or more, preferably about 70 wt% to about 75 wt%, relative to the total weight of the tribromocumene mixture. The unsubstituted tribromobenzenes are about 5 wt% or more, preferably about 5 wt% to about 10 wt%, relative to the total weight of the tribromocumene mixture. The unsubstituted tribromobenzenes preferably comprise 1,2,4-tribromobenzene in an amount of about 5 wt% or more, preferably about 6 wt% or more, more preferably about 5 wt% to about 10 wt%, relative to the total weight of the tribromocumene mixture. Another tribromobenzene that is preferably present in the tribromocumene mixture is 1,3,5-tribromobenzene, preferably in an amount of about 0.75 wt% or more, more preferably 0.75 wt% to about 1.5 wt%, relative to the total weight of the tribromocumene mixture. Often, other brominated cumene species are also present in the tribromocumene mixture, often in a total amount of about 5 wt% or more, preferably about 5 wt% to about 15 wt%, relative to the total weight of the relative to the total weight of the tribromocumene mixture. Typically, the other brominated cumene species are 2,3,5-tribromocumene, 3,4,5-tribromocumene, and 2,3,4,5-tetrabromocumene. A particularly preferred tribromocumene mixture comprises 2,4,5-tribromocumene in an amount of about 70 to about 73 wt%, 2,3,5-tribromocumene in an amount of about 3 wt% to about 5 wt%, 3,4,5-tribromocumene in an amount of about 1 wt% to about 2.5 wt%, 2,3,4,5-tetrabromocumene in an amount of about 7.5 wt% to about 9.5 wt%, 1,2,4,5-tetrabromobenzene in an amount of about 0.5 wt% to about 1.5 wt%, 1,2,4-tribromobenzene in an amount of about 6 wt% to about 8 wt%, and 1,3,5-tribromobenzene in an amount of about 1.25 wt% to about 2.5 wt%, relative to the total weight of the tribromocumene mixture. The bromine-containing mixtures comprising 2,4,5-tribromocumene often have densities of about 1.20 g/mL or more, preferably

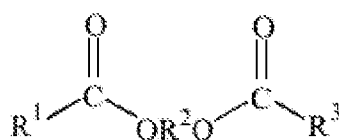
about 1.30 g/mL or more, more preferably about 1.40 g/mL or more, still more preferably about 1.50 g/mL or more.

**[0095]** The tribromocumene mixtures comprising 2,4,5-tribromocumene and one or more unsubstituted tribromobenzenes are prepared by a process comprising contacting cumene (isopropylbenzene) and a brominating agent, preferably elemental bromine, in the presence of an aluminum chloride catalyst. Preferably, about 2.5 moles to about 3.5 moles of the brominating agent are used per mole of cumene, and the aluminum chloride is used in a catalytic amount (typically about 0.2 wt% to about 0.6 wt%, preferably about 0.3 wt% to about 0.5 wt%, relative to the cumene). The process is normally conducted under an inert atmosphere (e.g., nitrogen, argon, or helium) in a liquid organic medium, typically a solvent or mixture of solvents in which cumene is soluble.

#### Other additives

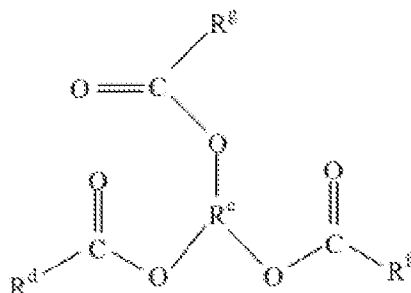
**[0096]** It is often useful to include one or more optional additives with the halogen-containing sorbents, especially in a well fluid, and the inclusion of such additives is within the scope of this invention. Optional additives can include, for example, weighting agents, corrosion inhibitors, lubricants, pH control additives, surfactants, and/or solvents.

**[0097]** Preferred types of optional additives in the practice of this invention are unsaturated diesters and saturated triesters that do not contain bromine. When the additive is an unsaturated diester, the unsaturated diester has at least eight carbon atoms and is represented by the formula



where  $\text{R}^1$  and  $\text{R}^3$  are hydrocarbyl groups, and  $\text{R}^2$  is an alkene-containing moiety.  $\text{R}^1$  and  $\text{R}^3$  can be straight chain, branched, cyclic, or aromatic; preferably the hydrocarbyl group is a straight chain. Suitable hydrocarbyl groups include methyl, ethyl, n-propyl, 2-propyl, n-butyl, pentyl, cyclopentyl, hexyl, and cyclohexyl; ethyl and n-propyl are preferred.  $\text{R}^2$  preferably has four to about eight carbon atoms, more preferably four to about six carbon atoms; suitable alkene-containing moieties include 2-butene, 2-pentene, 2-hexene, 3-hexene, 2-octene 3-octene, and 4-octene; preferred alkene-containing moieties include 2-butene.

[0098] When the additive is a saturated triester, the saturated triester has at least seven carbon atoms and is represented by the formula



where  $\text{R}^d$ ,  $\text{R}^e$ ,  $\text{R}^f$ , and  $\text{R}^g$  are hydrocarbyl groups.  $\text{R}^d$ ,  $\text{R}^f$ , and  $\text{R}^g$  can be straight chain, branched, or cyclic; preferably the hydrocarbyl group is a straight chain. Suitable hydrocarbyl groups include methyl, ethyl, n-propyl, 2-propyl, n-butyl, pentyl, cyclopentyl, hexyl, cyclohexyl, and phenyl; ethyl and n-propyl are preferred.  $\text{R}^e$  can be branched or cyclic, or aromatic; preferably  $\text{R}^e$  is a saturated branched chain. Suitable hydrocarbyl groups include propyl, butyl, 2-pentyl, 3-pentyl, cyclopentyl, 2-hexyl, 3-hexyl, and cyclohexyl; 2-propyl is a preferred group.

[0099] Suitable unsaturated diesters that do not contain bromine include but-2-ene-1,4-diyl diacetate, but-2-ene-1,4-diyl bis(propanoate), but-2-ene-1,4-diyl bis(butyrate), but-2-ene-1,4-diyl bis(pentanoate), pent-2-ene-1,5-diyl diacetate, pent-3-ene-1,5-diyl diacetate, pent-3-ene-1,5-diyl bis(propanoate); preferred is but-2-ene-1,4-diyl bis(butyrate). Suitable saturated triesters that do not contain bromine include propane-1,2,3-triyl triacetate, propane-1,2,3-triyl propanoate, propane-1,2,3-triyl tributryate; preferred is propane-1,2,3-triyl tributryate. Combinations of any two or more unsaturated diesters and/or saturated triesters can be used in the practice of the invention.

[00100] Processes for forming mixtures of a halogen-containing sorbent and an oil, which oil can be a paraffin, mineral, olefinic, or ester oil, comprise combining the oil and the halogen-containing sorbent in any order. For example, an oil and the halogen-containing sorbent can be added sequentially, or they can be introduced to a vessel or location simultaneously.

[00101] Any optional additives that are included can be combined with the halogen-containing sorbent in any convenient manner. When the halogen-containing sorbent is in a mixture with an oil, optional additives can be added before, during, and/or after formation of the mixture of an oil and the halogen-containing sorbent.

[00102] Although mixtures comprising weighting agents are preferably solids-free, at least in some instances, the halogen-containing sorbents form slurries or suspensions in oils and oil-

based well fluids. The halogen-containing sorbents can be part of a mixture containing one or more solids, for example a solid weighting agent such as barite, if desired.

**[00103]** In some well fluids, the presence of some solids is not disadvantageous. Calcium carbonate is often present as a suspension in a well fluid. The calcium carbonate often forms a filter cake that prevents the drilling fluid from entering the formation. After drilling, an acid treatment can be used to remove the calcium carbonate filter cake.

**[00104]** One or more halogen-containing sorbents can be combined with an oil-based well fluid. The oil-based well fluid can be a drilling fluid, a packer fluid, a screen running fluid, a (reservoir) drill-in fluid, a completion fluid, or a workover fluid. The halogen-containing sorbents can be combined with the well fluid alone or in admixture with one or more other additives and/or in a mixture with an oil.

**[00105]** The halogen-containing sorbents of the invention can be used as secondary fluids ("kill fluids") to minimize or relieve sustained casing pressure in a wellbore annulus. The term "annular fluid" refers to the first fluid, which is present in the wellbore annulus before the second fluid is introduced. The second fluid can be introduced at the wellhead or below the surface of the annular fluid; subsurface introduction of the kill fluid is generally preferred. For treating sustained casing pressure, immiscibility refers to the non-mixing or substantial non-mixing of the fluid comprising the halogen-containing sorbent(s) and the (aqueous) annular fluid. See in this connection International Publication WO 2015/100004.

**[00106]** The halogen-containing sorbents can be used as additives for hydraulic fluids. Preferably, the halogen-containing sorbent is about 35 wt% or more relative to the total weight of the hydraulic fluid and the halogen-containing sorbent. In terms of bromine content, there is about 20 wt% to about 70 wt% bromine relative to the total weight of the hydraulic fluid and the halogen-containing sorbent. Other additives, such as antioxidants, lubricity agents, and metal deactivators, may also be present in the hydraulic fluid.

**[00107]** Further embodiments of the invention include, without limitation:

**[00108]** A) An oil-based well fluid comprising a halogen-containing sorbent, which sorbent comprises one or more halogens selected from fluorine, chlorine, bromine, and/or iodine, and one or more substrate materials.

**[00109]** B) An oil-based well fluid according to A) wherein the halogen-containing sorbent comprises a substrate material selected from one or more carbonaceous materials and/or selected from one or more inorganic materials.

[00110] C) An oil-based well fluid according to B) wherein the carbonaceous material is activated carbon, and/or wherein the inorganic material is selected from inorganic oxides, natural zeolites, inorganic carbonates, and clay minerals.

[00111] D) An oil-based well fluid according to any of B)-C) wherein the inorganic material is selected from chabazite, silica, kaolinite, and bentonite.

[00112] E) An oil-based well fluid according to any of A)-D) wherein the halogen-containing sorbent is a bromine-containing sorbent.

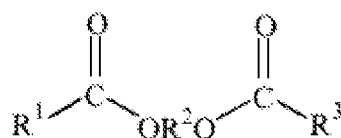
[00113] F) An oil-based well fluid according to A) wherein the halogen-containing sorbent is a halogen-containing activated carbon sorbent.

[00114] G) An oil-based well fluid according to A) wherein the halogen-containing sorbent is a bromine-containing activated carbon sorbent.

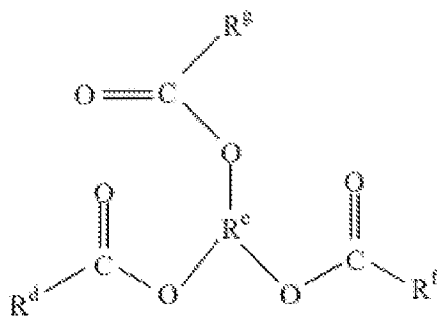
[00115] H) An oil-based well fluid according to any of A)-G) wherein the halogen-containing sorbent has a halogen content of about 0.1 wt% to about 50 wt% calculated as bromine and based on the total weight of the halogen-containing sorbent.

[00116] I) An oil-based well fluid as in any of A)-H) which further comprises barite.

[00117] J) An oil-based well fluid as in any of A)-I) which further comprises one or more additives selected from unsaturated diesters that do not contain bromine and/or saturated triesters that do not contain bromine, wherein the unsaturated diester has at least eight carbon atoms and is represented by the formula



where  $\text{R}^1$  and  $\text{R}^3$  are hydrocarbyl groups, and  $\text{R}^2$  is an alkene-containing moiety, and wherein the saturated triester has at least seven carbon atoms and is represented by the formula



where  $\text{R}^d$ ,  $\text{R}^e$ ,  $\text{R}^f$ , and  $\text{R}^g$  are hydrocarbyl groups.

[00118] K)11. An oil-based well fluid as in J) wherein the unsaturated diester is but-2-ene-1,4-diyl bis(butyrate), and wherein the saturated triester is propane-1,2,3-triyl tributrate.

[00119] L)12. An oil-based well fluid as in any of A)-K) which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine content of about 35 wt% or more, which bromine-containing organic compound is selected from

- a) a bromine-containing monoether compound comprising an oxygen atom and two groups bound thereto, in which a first group contains a terminal alkene moiety or an aromatic-alkyl moiety, wherein the oxygen atom is not bound to an alkenyl carbon atom or an aromatic carbon atom, and a second group selected from a hydrocarbyl group, a trihydrocarbylsilyl group, and a group comprising a terminal alkene moiety or an aromatic-alkyl moiety, in which the oxygen atom is not bound to an alkenyl carbon atom or an aromatic carbon atom, wherein the bromine-containing monoether compound is
  - i) a bromine-containing monoether compound which has four or more carbon atoms and a terminal alkene moiety,
  - ii) a bromine-containing monoether compound which has eight or more carbon atoms and an aromatic-alkyl moiety;
- b) a bromine-containing diether compound comprising two oxygen atoms and three groups, wherein:
 

one or more of the three groups contains an internal alkene moiety, a terminal alkene moiety, or an aromatic-alkyl moiety,

the three groups are comprised of two end groups, each bound to one of the two oxygen atoms, and a middle group bound to both of the oxygen atoms,

each end group that does not contain an internal alkene moiety, a terminal alkene moiety, or an aromatic-alkyl moiety is a hydrocarbyl group or a trihydrocarbylsilyl group and the middle group that does not contain an internal alkene moiety, a terminal alkene moiety, or an aromatic-alkyl moiety is a hydrocarbylenyl group or a dihydrocarbylsilylenyl group; and

the oxygen atoms are not bound to an alkenyl carbon atom or an aromatic carbon atom, wherein the bromine-containing diether compound is

- i) a bromine-containing diether compound which has six or more carbon atoms and an internal alkene moiety,
  - ii) a bromine-containing diether compound which has five or more carbon atoms and a terminal alkene moiety,
  - iii) a bromine-containing diether compound which has nine or more carbon atoms and an aromatic-alkyl moiety; and
- c) any two or more of the foregoing bromine-containing organic compounds.

**[00120]** M) An oil-based well fluid as in L) wherein

the bromine-containing monoether compound has a terminal alkene moiety and five to about twelve carbon atoms in the molecule;

the bromine-containing monoether compound has an aromatic-alkyl moiety and eight or more carbon atoms in the molecule;

the bromine-containing diether compound has an internal alkene moiety and six to about fifteen carbon atoms in the molecule;

the bromine-containing diether compound has a terminal alkene moiety and five to about twenty carbon atoms in the molecule; and

the bromine-containing diether compound has an aromatic-alkyl moiety and nine to about thirty carbon atoms in the molecule.

**[00121]** N) An oil-based well fluid as in L) wherein

the bromine-containing monoether compound comprising a terminal alkene moiety has four to about fifteen carbon atoms in the group comprising the terminal alkene moiety;

the bromine-containing monoether compound comprising an aromatic-alkyl moiety has eight to about twenty carbon atoms in the group comprising the aromatic-alkyl moiety;

the bromine-containing diether compound comprising an internal alkene moiety has six to about fifteen carbon atoms in the group comprising the internal alkene moiety;

the bromine-containing diether compound comprising a terminal alkene moiety has five to about twenty carbon atoms in the group comprising the terminal alkene moiety;  
the bromine-containing diether compound comprising an aromatic-alkyl moiety has nine to about thirty carbon atoms in the group comprising the aromatic-alkyl moiety.

**[00122]** O) An oil-based well fluid as in L) wherein

the bromine-containing monoether compound comprising an aromatic-alkyl moiety has an alkyl portion containing one to about four carbon atoms;  
the bromine-containing diether compound comprising an aromatic-alkyl moiety has an alkyl portion containing one to about four carbon atoms.

**[00123]** P) An oil-based well fluid as in L) wherein

the bromine-containing monoether compound has a second group selected from a hydrocarbyl group and a trihydrocarbylsilyl group;  
the bromine-containing diether compound has an end group selected from a hydrocarbyl group and a trihydrocarbylsilyl group;  
the bromine-containing diether compound has a middle group selected from a hydrocarbylenyl group or a dihydrocarbylsilylenyl group.

**[00124]** Q) An oil-based well fluid as in L) wherein

the bromine-containing monoether compound has a second group which is a trimethylsilyl group or a triethylsilyl group;  
the bromine-containing diether compound has an end group which is a trimethylsilyl group or a triethylsilyl group;  
the bromine-containing diether compound has a middle group which is a dimethylsilylenyl group or a diethylsilylenyl group.

**[00125]** R) An oil-based well fluid as in L) wherein

the bromine-containing monoether compound comprising a terminal alkene moiety has a 2-propenyl moiety;  
the bromine-containing diether compound comprising an internal alkene moiety has a 2-butene moiety;  
the bromine-containing diether compound comprising a terminal alkene moiety has a 2-propenyl moiety.

**[00126]** S) An oil-based well fluid as in any of L)-R) wherein the bromine content is about 40 wt% or more and/or wherein the bromine atoms are bound to alkenyl carbon atoms or aromatic carbon atoms.

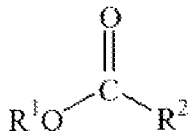
[00127] T) An oil-based well fluid as in any of L)-S) wherein two or more bromine atoms are bound to alkenyl carbon atoms or to aromatic carbon atoms.

[00128] U) An oil-based well fluid as in any of L)-S) wherein the bromine-containing organic compound is

1,2-dibromo-3-ethoxyprop-1-ene;  
 (1E)-1,2-dibromo-3-trimethylsilyloxyprop-1-ene;  
 3,5-dibromobenzyloxy-trimethylsilane;  
 (2E)-2,3-dibromo-1,4-diethoxybut-2-ene;  
 (2E)-2,3-dibromo-1,4-dipropoxybut-2-ene;  
 (2E)-2,3-dibromo-1,4-bis(trimethylsilyloxy)but-2-ene;  
 dimethyl[bis(2E)-2,3-dibromoprop-2-en-1-yl-oxy]silane; and/or  
 bis-(3,5-dibromobenzyloxy)-dimethylsilane.

[00129] V) An oil-based well fluid as in any of A)-K) which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine content of about 35 wt% or more, which bromine-containing organic compound is selected from

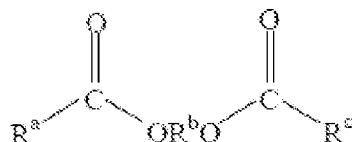
A) a bromine-containing monoester represented by the formula



wherein  $\text{R}^1$  contains a quaternary carbon atom, a terminal alkene moiety, or an aromatic-alkyl moiety, wherein the oxygen atom adjacent to  $\text{R}^1$  is not bound to a quaternary carbon atom, an alkenyl carbon atom or an aromatic carbon atom, and  $\text{R}^2$  is a hydrocarbyl group or a bromine-containing hydrocarbyl group, wherein the bromine-containing monoester is

- i) a bromine-containing monoester that has seven or more carbon atoms and  $\text{R}^1$  contains a quaternary carbon atom,
- ii) a bromine-containing monoester that has five or more carbon atoms and  $\text{R}^1$  contains a terminal alkene moiety,
- iii) a bromine-containing monoester that has nine or more carbon atoms and  $\text{R}^1$  contains an aromatic-alkyl moiety;

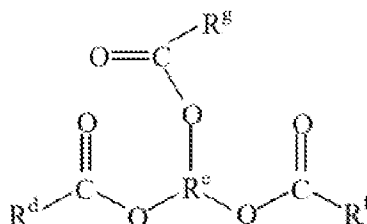
B) a bromine-containing diester represented by the formula



wherein  $R^b$  contains a quaternary carbon atom or an internal alkene moiety, wherein the oxygen atoms adjacent to  $R^b$  are not bound to a quaternary carbon atom or an alkenyl carbon atom, and  $R^a$  and  $R^c$  are each, independently, a hydrocarbyl group or a bromine-containing hydrocarbyl group, wherein the bromine-containing diester is

- i) a bromine-containing diester that has nine or more carbon atoms and  $R^b$  contains a quaternary carbon atom,
- ii) a bromine-containing diester that has eight or more carbon atoms and  $R^b$  contains an internal alkene moiety,

C) a bromine-containing triester which has at least seven carbon atoms and is represented by the formula



wherein  $R^d$ ,  $R^e$ ,  $R^f$ , and  $R^g$  are each, independently, a hydrocarbyl group or a bromine-containing hydrocarbyl group, and at least one of  $R^d$ ,  $R^e$ ,  $R^f$ , and  $R^g$  is a bromine-containing hydrocarbyl group; and

D) any two or more of the foregoing.

[00130] W) An oil-based well fluid as in V) wherein

the bromine-containing monoester in which  $R^1$  contains a quaternary carbon atom has seven to about twenty carbon atoms in the molecule;

the bromine-containing monoester in which  $R^1$  contains a terminal alkene moiety has five to about twenty carbon atoms in the molecule;

the bromine-containing monoester in which  $R^1$  contains an aromatic-alkyl moiety has nine to about twenty carbon atoms in the molecule;

the bromine-containing diester in which  $R^b$  contains a quaternary carbon atom has nine to about thirty carbon atoms in the molecule; and

the bromine-containing diester in which  $R^b$  contains an internal alkene moiety has eight to about thirty carbon atoms in the molecule.

[00131] X) An oil-based well fluid as in V) wherein

the bromine-containing monoester in which  $R^1$  contains a quaternary carbon atom has five to about fifteen carbon atoms in  $R^1$ ;

the bromine-containing monoester in which  $R^1$  contains a terminal alkene moiety has three to about ten carbon atoms in  $R^1$ ;

the bromine-containing monoester in which  $R^1$  contains an aromatic-alkyl moiety has seven to about fifteen carbon atoms in  $R^1$ ;

the bromine-containing diester in which  $R^b$  contains a quaternary carbon atom has five to about ten carbon atoms in  $R^b$ ; and

the bromine-containing diester in which  $R^b$  contains an internal alkene moiety has four to about eight carbon atoms in  $R^b$ .

[00132] Y) An oil-based well fluid as in V) wherein the bromine-containing monoester in which  $R^1$  contains an aromatic-alkyl moiety has an alkyl portion containing one to about four carbon atoms.

[00133] Z) An oil-based well fluid as in V) wherein

$R^2$  of the bromine-containing monoester is a hydrocarbyl group which is a saturated straight chain or a saturated branched chain;

$R^a$  or  $R^c$  of the bromine-containing diester is a hydrocarbyl group which is a saturated straight chain or a saturated branched chain;

$R^a$  or  $R^c$  of the bromine-containing diester is a bromine-containing hydrocarbyl group which is a saturated straight chain or a saturated branched chain.

[00134] AA) An oil-based well fluid as in V) wherein

$R^1$  of the bromine-containing monoester has a 2,2-dimethylprop-1-yl moiety as the quaternary carbon moiety;

$R^1$  of the bromine-containing monoester has a 2-propenyl moiety as the terminal alkene moiety;

$R^1$  of the bromine-containing monoester has a phenylmethyl moiety as the aromatic-alkyl moiety;

$R^b$  of the bromine-containing diester has a 2,2-dimethylpropane-1,3-diyl moiety as quaternary carbon atom moiety;

$R^b$  of the bromine-containing diester has a 2-butene moiety as the internal alkene moiety.

**[00135]** AB) An oil-based well fluid as in any of V)-AA) wherein two or more bromine atoms are bound to carbon atoms adjacent to quaternary carbon atoms, to alkenyl carbon atoms, or to aromatic carbon atoms.

**[00136]** AC) An oil-based well fluid as in any of V)-AB) wherein the bromine-containing organic compound is 3-bromo-2,2-bis(bromomethyl)propyl acetate; 3-bromo-2,2-bis(bromomethyl)propyl propionate; 3-bromo-2,2-bis(bromomethyl)propyl butyrate; 3-bromo-2,2-bis(bromomethyl)propyl 2-methylpropanoate; 3-bromo-2,2-bis(bromomethyl)propyl pentanoate; 3-bromo-2,2-bis(bromomethyl)propyl isovalerate; 3-bromo-2,2-bis(bromomethyl)propyl hexanoate; 2,3-dibromoallyl acetate; 2,3-dibromoallyl propionate; 2,3-dibromoallyl 2-methylpropanoate; (3,5-dibromophenyl)methyl acetate; (3,5-dibromophenyl)methyl bromoacetate; (3,5-dibromophenyl)methyl propionate; (3,5-dibromophenyl)methyl butyrate; (3,5-dibromophenyl)methyl 2-methylpropanoate; (3,5-dibromophenyl)methyl pentanoate; 2,2-bis(bromomethyl) 1,3-diacetoxyp propane; 2,2-bis(bromomethyl)1,3-propanediol-1,3-dipropionate; 2,2-bis(bromomethyl)1,3-propanediol-1,3-di(2-methylpropanoate); 2,2-bis(bromomethyl)1,3-propanediol-1,3-dihexanoate; 2,2-bis(bromomethyl)1,3-propanediol-1,3-bis-(bromoacetate); (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(propionate); (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate); (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2'-bromobutyrate); (2Z)-but-2-ene-1,4-diyl bis(bromoacetate); and/or 1,2,3-propanetriyl tris(bromoacetate).

**[00137]** AD) An oil-based well fluid as in AC) wherein the bromine-containing organic compound is (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(propionate).

**[00138]** AE) An oil-based well fluid as in V) wherein the bromine-containing organic compound is a mixture of diesters selected from

- a) 2,2-bis(bromomethyl)propane-1,3-diyl di(bromoacetate), 3-bromo-2-[[[(bromoacetyl)oxy]methyl]-2-(bromomethyl)propyl hexanoate, and 2,2-bis(bromomethyl)propane-1,3-diyl dihexanoate;
- b) (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutanoate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl butanoate;
- c) (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl 2-methylpropanoate;

- d) (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(bromoacetate), (2E)-2,3-dibromo-4-[(bromoacetyl)oxy]but-2-en-1-yl hexanoate, and (2E)-2,3-dibromobut-2-ene-1,4-diyl dihexanoate;
- e) (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(bromoacetate), and (2E)-2,3-dibromo-4-[(bromoacetyl)oxy]but-2-en-1-yl 2-methylpropanoate;
- f) (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(3-methylbutanoate), and (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl 3-methylbutanoate;
- g) (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dilineolate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl lineolate;
- h) (2E)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2E)-2,3-dibromobut-2-ene-1,4-diyl propionate, (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl acetate, (2Z)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2Z)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, and (2Z)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl acetate;
- i) (2E)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2E)-2,3-dibromobut-2-ene-1,4-diyl di(2-methylpropanoate), (2E)-2,3-dibromo-4-[2-methylpropionyl]oxy]but-2-en-1-yl acetate, (2Z)-3-but-2-ene-1,4-diyl diacetate, (2Z)-but-2-ene-1,4-diyl dipropionate, and (2Z)-but-2-ene-4-[(propionyl)oxy]but-2-en-1-yl acetate;
- j) (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutanoate and 2,2-bis(bromomethyl)propane-1,3-diyl dibutanoate;
- k) 2,2-bis(bromomethyl)propane-1,3-diyl diacetate, 2,2-bis(bromomethyl)propane-1,3-diyl dipropionate, 2,2-bis(bromomethyl)propane-1,3-diyl di(2-methylpropanoate), 3-bromo-2-[[acetyloxy]methyl]-2-(bromomethyl)propyl propionate, 3-bromo-2-[[acetyloxy]methyl]-2-(bromomethyl)propyl 2-methylpropanoate, 3-bromo-2-[[propionyl]oxy]methyl]-2-(bromomethyl)propyl 2-methylpropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, (2E)-2,3-dibromobut-2-ene-1,4-diyl di(2-methylpropanoate), (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl acetate, (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl propionate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl acetate;
- l) 2,2-bis(bromomethyl)propane-1,3-diyl dipropionate, 2,2-bis(bromomethyl)propane-1,3-diyl dibutyrate, 2,2-bis(bromomethyl)propane-1,3-diyl di(2-methylpropanoate), 3-

bromo-2-[(propionyl)oxy]methyl]-2-(bromomethyl)propyl butyrate, 3-bromo-2-[(propionyl)oxy]methyl]-2-(bromomethyl)propyl 2-methylpropanoate, 3-bromo-2-[(butyryloxy)methyl]-2-(bromomethyl)propyl 2-methylpropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutyrate, (2E)-2,3-dibromobut-2-ene-1,4-diyl di(2-methylpropanoate), (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl propionate, (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl butyrate, and (2E)-2,3-dibromo-4-[(butyryl)oxy]but-2-en-1-yl propionate; and

- m) propane-1,2,3-triyl tris(bromoacetate), propane-1,2,3-triyl tris(hexanoate), propane-1,2,3-triyl bis(bromoacetate)(hexanoate), and propane-1,2,3-triyl (bromoacetate)bis(hexanoate).

**[00139]** AF) An oil-based well fluid as in AE) which is a mixture of diesters selected from

- a mixture comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutanoate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl butanoate;
- a mixture comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl 2-methylpropanoate;
- a mixture comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dilineolate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-ene-1-yl lineolate; and
- a mixture comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2E)-2,3-dibromobut-2-ene-1,4-diyl di(2-methylpropanoate), (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl acetate, (2Z)-but-2-ene-1,4-diyl diacetate, (2Z)-but-2-ene-1,4-diyl di(2-methylpropionate), and (2Z)-1-[(2-methylpropionyl)oxy]but-2-ene-4-yl acetate.

**[00140]** AG) An oil-based well fluid as in AF) which is a combination of a mixture of esters comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutanoate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl butanoate with propane-1,2,3-triyl tributrylate.

**[00141]** AH) An oil-based well fluid as in any of A)-K) which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine

content of about 35 wt% or more, which bromine-containing organic compound is selected from

- a) a bromine-containing saturated cyclic diether comprising two or more bromine atoms, and a saturated ring comprising two oxygen atoms and four or more carbon atoms, the saturated ring having one or more hydrocarbyl substituents, each bound to a carbon atom of the saturated ring, wherein each bromine atom is bound to a hydrocarbyl substituent in a position on the hydrocarbyl substituent that does not have beta hydrogen atoms;
- b) a bromine-containing aromatic diether comprising one phenyl ring having two or three bromine atoms bound to the phenyl ring and at least one oxygen-containing group bound to the phenyl ring via an oxygen atom, with the proviso that when there is only one oxygen-containing group, the oxygen-containing group is an alkoxyether group; and
- c) any two or more of the foregoing.

[00142] AI) An oil-based well fluid as in AH) wherein

the bromine-containing saturated cyclic diether has four to about fifteen carbon atoms in the molecule;

the bromine-containing aromatic diether has about eight to about twenty carbon atoms in the molecule.

[00143] AJ) An oil-based well fluid as in AH) wherein

the bromine-containing saturated cyclic diether has a saturated ring which is a five-membered ring or a six-membered ring;

the bromine-containing aromatic diether has one oxygen-containing group bound to the phenyl ring, which oxygen-containing group is an alkoxyether group.

[00144] AK) An oil-based well fluid as in AH) wherein

the bromine-containing saturated cyclic diether has one to about three hydrocarbyl substituents on the saturated ring;

the bromine-containing aromatic diether has one oxygen-containing group bound to the phenyl ring, and at least one bromine atom is adjacent to the oxygen-containing group.

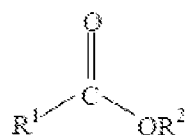
[00145] AL) An oil-based well fluid as in AH) wherein the bromine-containing aromatic diether has two oxygen-containing groups bound to the phenyl ring, which oxygen-containing groups are an alkoxyether group and a hydrocarbyloxy group.

[00146] AM) An oil-based well fluid as in any of AH)-AL) wherein bromine content is about 40 wt% or more.

[00147] AN) An oil-based well fluid as in any of AH)-AM) which is 5,5-bis(bromomethyl)-2-ethyl-1,3-dioxane, 1,3-dibromo-4-(2-ethoxy)ethoxybenzene, and/or 1,2-dibromo-4-butoxy-5-ethoxybenzene.

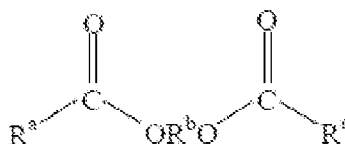
[00148] AO) An oil-based well fluid as in any of A)-K) which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine content of about 35 wt% or more, which bromine-containing organic compound is selected from

- a) a bromine-containing monoester represented by the formula



wherein  $\text{R}^1$  contains a phenyl ring having two or more bromine atoms bound thereto and  $\text{R}^2$  is a saturated hydrocarbyl group or an oxygen-containing group which is an ether group or a polyether group;

- b) a mixture of bromine-containing esters comprising a bromine-containing monoester as in a) and a bromine-containing diester a phenyl ring having two or more bromine atoms bound thereto and having two  $-(\text{C}=\text{O})\text{OR}^3$  moieties bound to the phenyl ring where each  $\text{R}^3$  is a saturated hydrocarbyl group or an oxygen-containing group which is an ether group or a polyether group;
- c) a mixture of bromine-containing diesters, each having eight or more carbon atoms and each represented by the formula



wherein  $\text{R}^b$  contains an internal alkene moiety, wherein the oxygen atoms adjacent to  $\text{R}^b$  are not bound to an alkenyl carbon atom, and  $\text{R}^a$  and  $\text{R}^c$  are each, independently, a hydrocarbyl group or a chlorine-containing hydrocarbyl group, with the proviso that in one or more of the bromine-containing diesters in the mixture at least one of  $\text{R}^a$  and  $\text{R}^c$  is a chlorine-containing hydrocarbyl group;

- d) a mixture of bromine-containing diesters comprising

bis (2-ethylhexyl) adipate,

2,2-bis(bromomethyl)propane-1,3-diyl bis[1-O-hexanedionyl(6-O-2-ethylhexanoate)],

3-bromo-2-[[[(hexanoyl)oxy]methyl]-2-(bromomethyl)propyl [1-O-hexanedionyl(6-O-2-ethylhexanoate)], and

3,3,14,14-tetra(bromomethyl)-1,5,12,16-tetraoxacyclodocosane-6,11,17,22-tetrone;

e) any two or more of the foregoing.

[00149] AP) An oil-based well fluid as in AO) wherein

the bromine-containing monoester has eight to about thirty carbon atoms in the molecule; in the bromine-containing diester in the mixture of bromine-containing esters which has a phenyl ring, the diester has ten to about forty carbon atoms; and each of the diesters in the mixtures of bromine-containing diesters in which R<sup>b</sup> contains an internal alkene moiety has eight to about thirty carbon atoms in the molecule.

[00150] AQ) An oil-based well fluid as in AO) wherein

the bromine-containing monoester has six to about fifteen carbon atoms in R<sup>1</sup>; and each of the diesters in the mixtures of bromine-containing diesters in which R<sup>b</sup> contains an internal alkene moiety has four to about eight carbon atoms in R<sup>b</sup>.

[00151] AR) An oil-based well fluid as in AO) wherein

R<sup>2</sup> of the bromine-containing monoester is a saturated branched chain; and in the bromine-containing diester in the mixture of bromine-containing esters which has a phenyl ring, R<sup>3</sup> has a saturated branched chain; in the mixture of bromine-containing diesters in which R<sup>b</sup> contains an internal alkene moiety, R<sup>a</sup> or R<sup>c</sup> of the bromine-containing diester is a hydrocarbyl group which is a saturated straight chain or a saturated branched chain or a chlorine-containing hydrocarbyl group which is a saturated straight chain or a saturated branched chain.

[00152] AS) An oil-based well fluid as in AO) wherein R<sup>b</sup> in the mixture of bromine-containing diesters has a 2-butene moiety as the internal alkene moiety.

[00153] AT) An oil-based well fluid as in any of AO)-AS) wherein the bromine atoms in the mixture of bromine-containing diesters in which R<sup>b</sup> contains an internal alkene moiety are bound to alkenyl carbon atoms.

[00154] AU) An oil-based well fluid as in any of AO)-AT) wherein the bromine-containing organic compound is 4-butyloctyl 2,3,4,5-tetrabromobenzoate; a mixture of bromine-containing esters comprising 2-butyloctyl 2,3,4,5-tetrabromobenzoate and di(2-butyloctyl) 3,4,5,6-tetrabromophthalate; and/or a mixture of diesters comprising (2E)-2,3-dibromobut-2-

ene-1,4-diyl bis(2-methylpropanoate), (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(trichloroacetate), and (2E)-2,3-dibromo-4-[(trichloroacetyl)oxy]but-2-en-1-yl 2-methylpropanoate.

**[00155]** AV) An oil-based well fluid as in any of A)-K) which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine content of about 50 wt% or more, which bromine-containing organic compound is selected from

- a) a bromine-containing terminal alkene having three or more carbon atoms in the molecule
- b) a bromine-containing internal alkene having four or more carbon atoms in the molecule;
- c) a tribromocumene mixture comprising 2,4,5-tribromocumene and one or more unsubstituted tribromobenzenes, wherein 2,4,5-tribromocumene is about 70 wt% or more relative to the total weight of the tribromocumene mixture, and the unsubstituted tribromobenzenes are about 5 wt% or more, relative to the total weight of the mixture;
- d) any two or more of the foregoing bromine-containing organic compounds.

**[00156]** AW) An oil-based well fluid as in AV) wherein

the bromine-containing terminal alkene has three to about six carbon atoms in the molecule;

the bromine-containing internal alkene has four to about eight carbon atoms in the molecule;

the tribromocumene mixture has 2,4,5-tribromocumene in an amount of about 70 wt% to about 75 wt%, relative to the total weight of the tribromocumene mixture, and/or unsubstituted tribromobenzenes in an amount of 5 wt% to about 10 wt%, relative to the total weight of the tribromocumene mixture.

**[00157]** AX) An oil-based well fluid as in AW) wherein

the bromine-containing terminal alkene has two or more bromine atoms bound to alkenyl carbon atoms;

the bromine-containing internal alkene has two or more bromine atoms bound to alkenyl carbon atoms;

the tribromocumene mixture contains as unsubstituted tribromobenzenes, 1,2,4-tribromobenzene in an amount of about 5 wt% or more, relative to the total weight of the tribromocumene mixture, and optionally 1,3,5-tribromobenzene, in an amount of about 0.75 wt% or more, relative to the total weight of the tribromocumene mixture.

[00158] AY) An oil-based well fluid as in AX) wherein the tribromocumene mixture contains 1,2,4-tribromobenzene in an amount of about 5 wt% to about 10 wt%, relative to the total weight of the tribromocumene mixture, and optionally 1,3,5-tribromobenzene, in an amount of about 0.75 wt% to about 1.5 wt%, relative to the total weight of the tribromocumene mixture.

[00159] AZ) An oil-based well fluid as in AX) or AY) wherein the total amount is about 5 wt% to about 15 wt%, relative to the total weight of the relative to the total weight of the tribromocumene mixture.

[00160] BA) An oil-based well fluid as in any of AX)-AZ) wherein 2,3,5-tribromocumene, 3,4,5-tribromocumene, and/or 2,3,4,5-tetrabromocumene are present in the tribromocumene mixture, in a total amount of about 5 wt% or more, relative to the total weight of the relative to the total weight of the tribromocumene mixture.

[00161] BB) An oil-based well fluid as in any of AV)-BA) wherein the bromine-containing organic compound is 1,2-dibromo-1-hexene, 2,3-dibromo-2-butene, 2,3,4,5-tetrabromo-2,4-hexadiene, and/or a tribromocumene mixture having 2,4,5-tribromocumene in an amount of about 70 to about 73 wt%, 2,3,5-tribromocumene in an amount of about 3 wt% to about 5 wt%, 3,4,5-tribromocumene in an amount of about 1 wt% to about 2.5 wt%, 2,3,4,5-tetrabromocumene in an amount of about 7.5 wt% to about 9.5 wt%, 1,2,4,5-tetrabromobenzene in an amount of about 0.5 wt% to about 1.5 wt%, 1,2,4-tribromobenzene in an amount of about 6 wt% to about 8 wt%, and 1,3,5-tribromobenzene in an amount of about 1.25 wt% to about 2.5 wt%, all relative to the total weight of the tribromocumene mixture.

[00162] BC) An oil-based well fluid as in any of A)-BB) wherein the well fluid is a drilling fluid, a packer fluid, a screen running fluid, a drill-in fluid, a completion fluid, or a workover fluid.

[00163] BD) A method of treating a wellbore, said method comprising introducing into the wellbore a fluid as in any of A)-BC).

[00164] BE) A method for minimizing or relieving a sustained casing pressure in an annulus of a wellbore, wherein the annulus contains a first fluid having a density, the method comprising introducing a second fluid into the annulus, wherein the second fluid has a density greater than the density of the first fluid and the second fluid is immiscible with the first fluid, characterized in that the second fluid comprises a halogen-containing sorbent, which sorbent comprises one or more halogens selected from fluorine, chlorine, bromine, and/or iodine, and one or more substrate materials.

[00165] BF) A mixture comprising an oil and a halogen-containing sorbent comprising one or more halogens selected from fluorine, chlorine, bromine, and/or iodine, and one or more substrate materials, in which mixture there is about 0.1 to about 30 wt% halogen-containing sorbent.

[00166] BG) A mixture as in BF) in combination with a hydraulic fluid.

[00167] Components referred to by chemical name or formula anywhere in the specification or claims hereof, whether referred to in the singular or plural, are identified as they exist prior to coming into contact with another substance referred to by chemical name or chemical type (*e.g.*, another component, a solvent, or *etc.*). It matters not what chemical changes, transformations and/or reactions, if any, take place in the resulting mixture or solution as such changes, transformations, and/or reactions are the natural result of bringing the specified components together under the conditions called for pursuant to this disclosure. Thus the components are identified as ingredients to be brought together in connection with performing a desired operation or in forming a desired composition. Also, even though the claims hereinafter may refer to substances, components and/or ingredients in the present tense ("comprises", "is", *etc.*), the reference is to the substance, component or ingredient as it existed at the time just before it was first contacted, blended or mixed with one or more other substances, components and/or ingredients in accordance with the present disclosure. The fact that a substance, component or ingredient may have lost its original identity through a chemical reaction or transformation during the course of contacting, blending or mixing operations, if conducted in accordance with this disclosure and with ordinary skill of a chemist, is thus of no practical concern.

[00168] The invention may comprise, consist, or consist essentially of the materials and/or procedures recited herein.

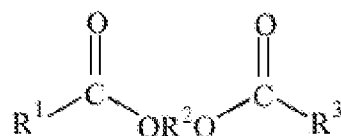
[00169] As used herein, the term "about" modifying the quantity of an ingredient in the compositions of the invention or employed in the methods of the invention refers to variation in the numerical quantity that can occur, for example, through typical measuring and liquid handling procedures used for making concentrates or use solutions in the real world; through inadvertent error in these procedures; through differences in the manufacture, source, or purity of the ingredients employed to make the compositions or carry out the methods; and the like. The term about also encompasses amounts that differ due to different equilibrium conditions for a composition resulting from a particular initial mixture. Whether or not modified by the term "about", the claims include equivalents to the quantities.

**[00170]** Except as may be expressly otherwise indicated, the article "a" or "an" if and as used herein is not intended to limit, and should not be construed as limiting, the description or a claim to a single element to which the article refers. Rather, the article "a" or "an" if and as used herein is intended to cover one or more such elements, unless the text expressly indicates otherwise.

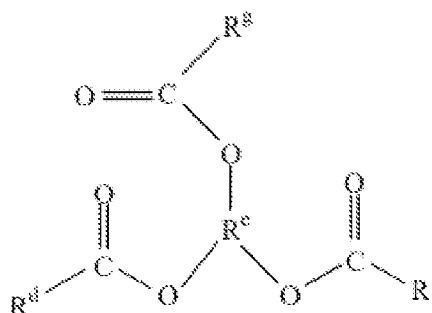
**[00171]** This invention is susceptible to considerable variation in its practice. Therefore the foregoing description is not intended to limit, and should not be construed as limiting, the invention to the particular exemplifications presented hereinabove.

**THAT WHICH IS CLAIMED IS:**

1. An oil-based well fluid comprising a halogen-containing sorbent, which sorbent comprises one or more halogens selected from fluorine, chlorine, bromine, and/or iodine, and one or more substrate materials.
2. An oil-based well fluid according to Claim 1 wherein the halogen-containing sorbent comprises a substrate material selected from one or more carbonaceous materials and/or selected from one or more inorganic materials.
3. An oil-based well fluid according to Claim 2 wherein the carbonaceous material is activated carbon, and/or wherein the inorganic material is selected from inorganic oxides, natural zeolites, inorganic carbonates, and clay minerals.
4. An oil-based well fluid according to any of Claims 2-3 wherein the inorganic material is selected from chabazite, silica, kaolinite, and bentonite.
5. An oil-based well fluid according to any of Claims 1-4 wherein the halogen-containing sorbent is a bromine-containing sorbent.
6. An oil-based well fluid according to Claim 1 wherein the halogen-containing sorbent is a halogen-containing activated carbon sorbent.
7. An oil-based well fluid according to Claim 1 wherein the halogen-containing sorbent is a bromine-containing activated carbon sorbent.
8. An oil-based well fluid according to any of Claims 1-7 wherein the halogen-containing sorbent has a halogen content of about 0.1 wt% to about 50 wt% calculated as bromine and based on the total weight of the halogen-containing sorbent.
9. An oil-based well fluid as in any of Claims 1-8 which further comprises barite.
10. An oil-based well fluid as in any of Claims 1-9 which further comprises one or more additives selected from unsaturated diesters that do not contain bromine and/or saturated triesters that do not contain bromine, wherein the unsaturated diester has at least eight carbon atoms and is represented by the formula



where  $R^1$  and  $R^3$  are hydrocarbyl groups, and  $R^2$  is an alkene-containing moiety, and wherein the saturated triester has at least seven carbon atoms and is represented by the formula



where  $R^d$ ,  $R^e$ ,  $R^f$ , and  $R^g$  are hydrocarbyl groups.

11. An oil-based well fluid as in Claim 9 wherein the unsaturated diester is but-2-ene-1,4-diyl bis(butyrate), and wherein the saturated triester is propane-1,2,3-triyl tributyrate.

12. An oil-based well fluid as in any of Claims 1-11 which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine content of about 35 wt% or more, which bromine-containing organic compound is selected from

- a) a bromine-containing monoether compound comprising an oxygen atom and two groups bound thereto, in which a first group contains a terminal alkene moiety or an aromatic-alkyl moiety, wherein the oxygen atom is not bound to an alkenyl carbon atom or an aromatic carbon atom, and a second group selected from a hydrocarbyl group, a trihydrocarbylsilyl group, and a group comprising a terminal alkene moiety or an aromatic-alkyl moiety, in which the oxygen atom is not bound to an alkenyl carbon atom or an aromatic carbon atom, wherein the bromine-containing monoether compound is
  - i) a bromine-containing monoether compound which has four or more carbon atoms and a terminal alkene moiety,

- ii) a bromine-containing monoether compound which has eight or more carbon atoms and an aromatic-alkyl moiety;
- b) a bromine-containing diether compound comprising two oxygen atoms and three groups, wherein:
  - one or more of the three groups contains an internal alkene moiety, a terminal alkene moiety, or an aromatic-alkyl moiety,
  - the three groups are comprised of two end groups, each bound to one of the two oxygen atoms, and a middle group bound to both of the oxygen atoms,
  - each end group that does not contain an internal alkene moiety, a terminal alkene moiety, or an aromatic-alkyl moiety is a hydrocarbyl group or a trihydrocarbylsilyl group and the middle group that does not contain an internal alkene moiety, a terminal alkene moiety, or an aromatic-alkyl moiety is a hydrocarbylenyl group or a dihydrocarbylsilylenyl group; and
  - the oxygen atoms are not bound to an alkenyl carbon atom or an aromatic carbon atom, wherein the bromine-containing diether compound is
    - i) a bromine-containing diether compound which has six or more carbon atoms and an internal alkene moiety,
    - ii) a bromine-containing diether compound which has five or more carbon atoms and a terminal alkene moiety,
    - iii) a bromine-containing diether compound which has nine or more carbon atoms and an aromatic-alkyl moiety; and
- c) any two or more of the foregoing bromine-containing organic compounds.

13. An oil-based well fluid as in Claim 12 wherein

the bromine-containing monoether compound has a terminal alkene moiety and five to about twelve carbon atoms in the molecule;

the bromine-containing monoether compound has an aromatic-alkyl moiety and eight or more carbon atoms in the molecule;

the bromine-containing diether compound has an internal alkene moiety and six to about fifteen carbon atoms in the molecule;

the bromine-containing diether compound has a terminal alkene moiety and five to about twenty carbon atoms in the molecule; and

the bromine-containing diether compound has an aromatic-alkyl moiety and nine to about thirty carbon atoms in the molecule.

14. An oil-based well fluid as in Claim 12 wherein  
the bromine-containing monoether compound comprising a terminal alkene moiety has four  
to about fifteen carbon atoms in the group comprising the terminal alkene moiety;  
the bromine-containing monoether compound comprising an aromatic-alkyl moiety has eight  
to about twenty carbon atoms in the group comprising the aromatic-alkyl moiety;  
the bromine-containing diether compound comprising an internal alkene moiety has six to  
about fifteen carbon atoms in the group comprising the internal alkene moiety;  
the bromine-containing diether compound comprising a terminal alkene moiety has five to  
about twenty carbon atoms in the group comprising the terminal alkene moiety;  
the bromine-containing diether compound comprising an aromatic-alkyl moiety has nine to  
about thirty carbon atoms in the group comprising the aromatic-alkyl moiety.
15. An oil-based well fluid as in Claim 12 wherein  
the bromine-containing monoether compound comprising an aromatic-alkyl moiety has an  
alkyl portion containing one to about four carbon atoms;  
the bromine-containing diether compound comprising an aromatic-alkyl moiety has an alkyl  
portion containing one to about four carbon atoms.
16. An oil-based well fluid as in Claim 12 wherein  
the bromine-containing monoether compound has a second group selected from a  
hydrocarbyl group and a trihydrocarbylsilyl group;  
the bromine-containing diether compound has an end group selected from a hydrocarbyl  
group and a trihydrocarbylsilyl group;  
the bromine-containing diether compound has a middle group selected from a  
hydrocarbylenyl group or a dihydrocarbylsilylenyl group.
17. An oil-based well fluid as in Claim 12 wherein  
the bromine-containing monoether compound has a second group which is a trimethylsilyl  
group or a triethylsilyl group;  
the bromine-containing diether compound has an end group which is a trimethylsilyl group or  
a triethylsilyl group;  
the bromine-containing diether compound has a middle group which is a dimethylsilylenyl  
group or a diethylsilylenyl group.
18. An oil-based well fluid as in Claim 12 wherein

the bromine-containing monoether compound comprising a terminal alkene moiety has a 2-propenyl moiety;

the bromine-containing diether compound comprising an internal alkene moiety has a 2-butene moiety;

the bromine-containing diether compound comprising a terminal alkene moiety has a 2-propenyl moiety.

19. An oil-based well fluid as in any of Claims 12-18 wherein the bromine content is about 40 wt% or more and/or wherein the bromine atoms are bound to alkenyl carbon atoms or aromatic carbon atoms.

20. An oil-based well fluid as in any of Claims 12-19 wherein two or more bromine atoms are bound to alkenyl carbon atoms or to aromatic carbon atoms.

21. An oil-based well fluid as in any of Claims 12-19 wherein the bromine-containing organic compound is

1,2-dibromo-3-ethoxyprop-1-ene;

(1E)-1,2-dibromo-3-trimethylsilyloxyprop-1-ene;

3,5-dibromobenzyloxy-trimethylsilane;

(2E)-2,3-dibromo-1,4-diethoxybut-2-ene;

(2E)-2,3-dibromo-1,4-dipropoxybut-2-ene;

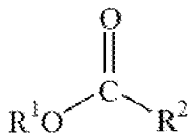
(2E)-2,3-dibromo-1,4-bis(trimethylsilyloxy)but-2-ene;

dimethyl[bis(2E)-2,3-dibromoprop-2-en-1-yl-oxy]silane; and/or

bis-(3,5-dibromobenzyloxy)-dimethylsilane.

22. An oil-based well fluid as in any of Claims 1-11 which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine content of about 35 wt% or more, which bromine-containing organic compound is selected from

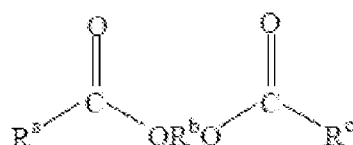
A) a bromine-containing monoester represented by the formula



wherein  $R^1$  contains a quaternary carbon atom, a terminal alkene moiety, or an aromatic-alkyl moiety, wherein the oxygen atom adjacent to  $R^1$  is not bound to a quaternary carbon atom, an alkenyl carbon atom or an aromatic carbon atom, and  $R^2$  is a hydrocarbyl group or a bromine-containing hydrocarbyl group, wherein the bromine-containing monoester is

- i) a bromine-containing monoester that has seven or more carbon atoms and  $R^1$  contains a quaternary carbon atom,
- ii) a bromine-containing monoester that has five or more carbon atoms and  $R^1$  contains a terminal alkene moiety,
- iii) a bromine-containing monoester that has nine or more carbon atoms and  $R^1$  contains an aromatic-alkyl moiety;

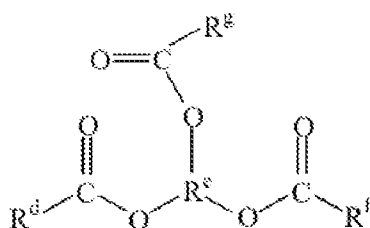
B) a bromine-containing diester represented by the formula



wherein  $R^b$  contains a quaternary carbon atom or an internal alkene moiety, wherein the oxygen atoms adjacent to  $R^b$  are not bound to a quaternary carbon atom or an alkenyl carbon atom, and  $R^a$  and  $R^c$  are each, independently, a hydrocarbyl group or a bromine-containing hydrocarbyl group, wherein the bromine-containing diester is

- i) a bromine-containing diester that has nine or more carbon atoms and  $R^b$  contains a quaternary carbon atom,
- ii) a bromine-containing diester that has eight or more carbon atoms and  $R^b$  contains an internal alkene moiety,

C) a bromine-containing triester which has at least seven carbon atoms and is represented by the formula



wherein  $R^d$ ,  $R^e$ ,  $R^f$ , and  $R^g$  are each, independently, a hydrocarbyl group or a bromine-containing hydrocarbyl group, and at least one of  $R^d$ ,  $R^e$ ,  $R^f$ , and  $R^g$  is a bromine-containing hydrocarbyl group; and

D) any two or more of the foregoing.

23. An oil-based well fluid as in Claim 22 wherein  
the bromine-containing monoester in which  $R^1$  contains a quaternary carbon atom has seven to about twenty carbon atoms in the molecule;  
the bromine-containing monoester in which  $R^1$  contains a terminal alkene moiety has five to about twenty carbon atoms in the molecule;  
the bromine-containing monoester in which  $R^1$  contains an aromatic-alkyl moiety has nine to about twenty carbon atoms in the molecule;  
the bromine-containing diester in which  $R^b$  contains a quaternary carbon atom has nine to about thirty carbon atoms in the molecule; and  
the bromine-containing diester in which  $R^b$  contains an internal alkene moiety has eight to about thirty carbon atoms in the molecule.

24. An oil-based well fluid as in Claim 22 wherein  
the bromine-containing monoester in which  $R^1$  contains a quaternary carbon atom has five to about fifteen carbon atoms in  $R^1$ ;  
the bromine-containing monoester in which  $R^1$  contains a terminal alkene moiety has three to about ten carbon atoms in  $R^1$ ;  
the bromine-containing monoester in which  $R^1$  contains an aromatic-alkyl moiety has seven to about fifteen carbon atoms in  $R^1$ ;  
the bromine-containing diester in which  $R^b$  contains a quaternary carbon atom has five to about ten carbon atoms in  $R^b$ ; and  
the bromine-containing diester in which  $R^b$  contains an internal alkene moiety has four to about eight carbon atoms in  $R^b$ .

25. An oil-based well fluid as in Claim 22 wherein the bromine-containing monoester in which  $R^1$  contains an aromatic-alkyl moiety has an alkyl portion containing one to about four carbon atoms.

26. An oil-based well fluid as in Claim 22 wherein

R<sup>2</sup> of the bromine-containing monoester is a hydrocarbonyl group which is a saturated straight chain or a saturated branched chain;

R<sup>a</sup> or R<sup>c</sup> of the bromine-containing diester is a hydrocarbonyl group which is a saturated straight chain or a saturated branched chain;

R<sup>a</sup> or R<sup>c</sup> of the bromine-containing diester is a bromine-containing hydrocarbonyl group which is a saturated straight chain or a saturated branched chain.

27. An oil-based well fluid as in Claim 22 wherein

R<sup>1</sup> of the bromine-containing monoester has a 2,2-dimethylprop-1-yl moiety as the quaternary carbon moiety;

R<sup>1</sup> of the bromine-containing monoester has a 2-propenyl moiety as the terminal alkene moiety;

R<sup>1</sup> of the bromine-containing monoester has a phenylmethyl moiety as the aromatic-alkyl moiety;

R<sup>b</sup> of the bromine-containing diester has a 2,2-dimethylpropane-1,3-diyl moiety as quaternary carbon atom moiety;

R<sup>b</sup> of the bromine-containing diester has a 2-butene moiety as the internal alkene moiety.

28. An oil-based well fluid as in any of Claims 22-27 wherein two or more bromine atoms are bound to carbon atoms adjacent to quaternary carbon atoms, to alkenyl carbon atoms, or to aromatic carbon atoms.

29. An oil-based well fluid as in any of Claims 22-28 wherein the bromine-containing organic compound is 3-bromo-2,2-bis(bromomethyl)propyl acetate; 3-bromo-2,2-bis(bromomethyl)propyl propionate; 3-bromo-2,2-bis(bromomethyl)propyl butyrate; 3-bromo-2,2-bis(bromomethyl)propyl 2-methylpropanoate; 3-bromo-2,2-bis(bromomethyl)propyl pentanoate; 3-bromo-2,2-bis(bromomethyl)propyl isovalerate; 3-bromo-2,2-bis(bromomethyl)propyl hexanoate; 2,3-dibromoallyl acetate; 2,3-dibromoallyl propionate; 2,3-dibromoallyl 2-methylpropanoate; (3,5-dibromophenyl)methyl acetate; (3,5-dibromophenyl)methyl bromoacetate; (3,5-dibromophenyl)methyl propionate; (3,5-dibromophenyl)methyl butyrate; (3,5-dibromophenyl)methyl 2-methylpropanoate; (3,5-dibromophenyl)methyl pentanoate; 2,2-bis(bromomethyl) 1,3-diacetoxyp propane; 2,2-bis(bromomethyl)1,3-propanediol-1,3-dipropionate; 2,2-bis(bromomethyl)1,3-propanediol-1,3-di(2-methylpropanoate); 2,2-bis(bromomethyl)1,3-propanediol-1,3-dihexanoate; 2,2-bis(bromomethyl)1,3-propanediol-1,3-bis-(bromoacetate); (2E)-2,3-dibromobut-2-ene-1,4-

diyl bis(propanoate); (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate); (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2'-bromobutyrate); (2Z)-but-2-ene-1,4-diyl bis(bromoacetate); and/or 1,2,3-propanetriyl tris(bromoacetate).

30. An oil-based well fluid as in Claim 29 wherein the bromine-containing organic compound is (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(propanoate).

31. An oil-based well fluid as in Claim 22 wherein the bromine-containing organic compound is a mixture of diesters selected from

- a) 2,2-bis(bromomethyl)propane-1,3-diyl di(bromoacetate), 3-bromo-2-[[[(bromoacetyl)oxy]methyl]-2-(bromomethyl)propyl hexanoate, and 2,2-bis(bromomethyl)propane-1,3-diyl dihexanoate;
- b) (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutanoate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl butanoate;
- c) (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl 2-methylpropanoate;
- d) (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(bromoacetate), (2E)-2,3-dibromo-4-[(bromoacetyl)oxy]but-2-en-1-yl hexanoate, and (2E)-2,3-dibromobut-2-ene-1,4-diyl dihexanoate;
- e) (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(bromoacetate), and (2E)-2,3-dibromo-4-[(bromoacetyl)oxy]but-2-en-1-yl 2-methylpropanoate;
- f) (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(3-methylbutanoate), and (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl 3-methylbutanoate;
- g) (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dilineolate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl lineolate;
- h) (2E)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2E)-2,3-dibromobut-2-ene-1,4-diyl propionate, (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl acetate, (2Z)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2Z)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, and (2Z)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl acetate;
- i) (2E)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2E)-2,3-dibromobut-2-ene-1,4-diyl di(2-methylpropanoate), (2E)-2,3-dibromo-4-[2-methylpropionyl]oxy]but-2-en-1-yl

- acetate, (2Z)-3-but-2-ene-1,4-diyl diacetate, (2Z)-but-2-ene-1,4-diyl dipropionate, and (2Z)-but-2-ene-4-[(propionyl)oxy]but-2-en-1-yl acetate;
- j) (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutanoate and 2,2-bis(bromomethyl)propane-1,3-diyl dibutanoate;
- k) 2,2-bis(bromomethyl)propane-1,3-diyl diacetate, 2,2-bis(bromomethyl)propane-1,3-diyl dipropionate, 2,2-bis(bromomethyl)propane-1,3-diyl di(2-methylpropanoate), 3-bromo-2-[[acetyloxy]methyl]-2-(bromomethyl)propyl propionate, 3-bromo-2-[[acetyloxy]methyl]-2-(bromomethyl)propyl 2-methylpropanoate, 3-bromo-2-[[propionyl]oxy]methyl]-2-(bromomethyl)propyl 2-methylpropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, (2E)-2,3-dibromobut-2-ene-1,4-diyl di(2-methylpropanoate), (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl acetate, (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl propionate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl acetate;
- l) 2,2-bis(bromomethyl)propane-1,3-diyl dipropionate, 2,2-bis(bromomethyl)propane-1,3-diyl dibutyrate, 2,2-bis(bromomethyl)propane-1,3-diyl di(2-methylpropanoate), 3-bromo-2-[[propionyl]oxy]methyl]-2-(bromomethyl)propyl butyrate, 3-bromo-2-[[propionyl]oxy]methyl]-2-(bromomethyl)propyl 2-methylpropanoate, 3-bromo-2-[[butyryloxy]methyl]-2-(bromomethyl)propyl 2-methylpropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutyrate, (2E)-2,3-dibromobut-2-ene-1,4-diyl di(2-methylpropanoate), (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl propionate, (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-en-1-yl butyrate, and (2E)-2,3-dibromo-4-[(butyryl)oxy]but-2-en-1-yl propionate; and
- m) propane-1,2,3-triyl tris(bromoacetate), propane-1,2,3-triyl tris(hexanoate), propane-1,2,3-triyl bis(bromoacetate)(hexanoate), and propane-1,2,3-triyl (bromoacetate)bis(hexanoate).
32. An oil-based well fluid as in Claim 31 which is a mixture of diesters selected from a mixture comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutanoate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-en-1-yl butanoate;

a mixture comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-ene-1-yl 2-methylpropanoate;

a mixture comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropionate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dilineolate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-ene-1-yl lineolate; and

a mixture comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl diacetate, (2E)-2,3-dibromobut-2-ene-1,4-diyl di(2-methylpropanoate), (2E)-2,3-dibromo-4-[(2-methylpropionyl)oxy]but-2-ene-1-yl acetate, (2Z)-but-2-ene-1,4-diyl diacetate, (2Z)-but-2-ene-1,4-diyl di(2-methylpropionate), and (2Z)-1-[(2-methylpropionyl)oxy]but-2-ene-4-yl acetate.

33. An oil-based well fluid as in Claim 32 which is a combination of a mixture of esters comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl dipropanoate, (2E)-2,3-dibromobut-2-ene-1,4-diyl dibutanoate, and (2E)-2,3-dibromo-4-[(propionyl)oxy]but-2-ene-1-yl butanoate with propane-1,2,3-triyl tributyrates.

34. An oil-based well fluid as in any of Claims 1-11 which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine content of about 35 wt% or more, which bromine-containing organic compound is selected from

- a) a bromine-containing saturated cyclic diether comprising two or more bromine atoms, and a saturated ring comprising two oxygen atoms and four or more carbon atoms, the saturated ring having one or more hydrocarbyl substituents, each bound to a carbon atom of the saturated ring, wherein each bromine atom is bound to a hydrocarbyl substituent in a position on the hydrocarbyl substituent that does not have beta hydrogen atoms;
- b) a bromine-containing aromatic diether comprising one phenyl ring having two or three bromine atoms bound to the phenyl ring and at least one oxygen-containing group bound to the phenyl ring via an oxygen atom, with the proviso that when there is only one oxygen-containing group, the oxygen-containing group is an alkoxyether group; and
- c) any two or more of the foregoing.

35. An oil-based well fluid as in Claim 34 wherein the bromine-containing saturated cyclic diether has four to about fifteen carbon atoms in the molecule;

the bromine-containing aromatic diether has about eight to about twenty carbon atoms in the molecule.

36. An oil-based well fluid as in Claim 34 wherein the bromine-containing saturated cyclic diether has a saturated ring which is a five-membered ring or a six-membered ring;

the bromine-containing aromatic diether has one oxygen-containing group bound to the phenyl ring, which oxygen-containing group is an alkoxyether group.

37. An oil-based well fluid as in Claim 34 wherein the bromine-containing saturated cyclic diether has one to about three hydrocarbyl substituents on the saturated ring;

the bromine-containing aromatic diether has one oxygen-containing group bound to the phenyl ring, and at least one bromine atom is adjacent to the oxygen-containing group.

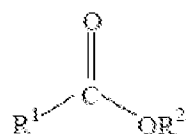
38. An oil-based well fluid as in Claim 34 wherein the bromine-containing aromatic diether has two oxygen-containing groups bound to the phenyl ring, which oxygen-containing groups are an alkoxyether group and a hydrocarbyloxy group.

39. An oil-based well fluid as in any of Claims 34-38 wherein bromine content is about 40 wt% or more.

40. An oil-based well fluid as in any of Claims 34-39 which is 5,5-bis(bromomethyl)-2-ethyl-1,3-dioxane, 1,3-dibromo-4-(2-ethoxy)ethoxybenzene, and/or 1,2-dibromo-4-butoxy-5-ethoxybenzene.

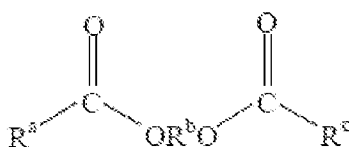
41. An oil-based well fluid as in any of Claims 1-11 which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine content of about 35 wt% or more, which bromine-containing organic compound is selected from

a) a bromine-containing monoester represented by the formula



wherein  $R^1$  contains a phenyl ring having two or more bromine atoms bound thereto and  $R^2$  is a saturated hydrocarbyl group or an oxygen-containing group which is an ether group or a polyether group;

- b) a mixture of bromine-containing esters comprising a bromine-containing monoester as in a) and a bromine-containing diester a phenyl ring having two or more bromine atoms bound thereto and having two  $-(C=O)OR^3$  moieties bound to the phenyl ring where each  $R^3$  is a saturated hydrocarbyl group or an oxygen-containing group which is an ether group or a polyether group;
- c) a mixture of bromine-containing diesters, each having eight or more carbon atoms and each represented by the formula



wherein  $R^b$  contains an internal alkene moiety, wherein the oxygen atoms adjacent to  $R^b$  are not bound to an alkenyl carbon atom, and  $R^a$  and  $R^c$  are each, independently, a hydrocarbyl group or a chlorine-containing hydrocarbyl group, with the proviso that in one or more of the bromine-containing diesters in the mixture at least one of  $R^a$  and  $R^c$  is a chlorine-containing hydrocarbyl group;

- d) a mixture of bromine-containing diesters comprising  
 bis (2-ethylhexyl) adipate,  
 2,2-bis(bromomethyl)propane-1,3-diyl bis[1-O-hexanedionyl(6-O-2-ethylhexanoate)],  
 3-bromo-2-[[[(hexanoyl)oxy]methyl]-2-(bromomethyl)propyl [1-O-hexanedionyl(6-O-2-ethylhexanoate)], and  
 3,3,14,14-tetra(bromomethyl)-1,5,12,16-tetraoxacyclodocosane-6,11,17,22-tetrone;
- e) any two or more of the foregoing.

42. An oil-based well fluid as in Claim 41 wherein  
 the bromine-containing monoester has eight to about thirty carbon atoms in the molecule;  
 in the bromine-containing diester in the mixture of bromine-containing esters which has a phenyl ring, the diester has ten to about forty carbon atoms; and  
 each of the diesters in the mixtures of bromine-containing diesters in which  $R^b$  contains an internal alkene moiety has eight to about thirty carbon atoms in the molecule.

43. An oil-based well fluid as in Claim 41 wherein the bromine-containing monoester has six to about fifteen carbon atoms in  $R^1$ ; and each of the diesters in the mixtures of bromine-containing diesters in which  $R^b$  contains an internal alkene moiety has four to about eight carbon atoms in  $R^b$ .
44. An oil-based well fluid as in Claim 41 wherein  $R^2$  of the bromine-containing monoester is a saturated branched chain; and in the bromine-containing diester in the mixture of bromine-containing esters which has a phenyl ring,  $R^3$  has a saturated branched chain; in the mixture of bromine-containing diesters in which  $R^b$  contains an internal alkene moiety,  $R^a$  or  $R^c$  of the bromine-containing diester is a hydrocarbyl group which is a saturated straight chain or a saturated branched chain or a chlorine-containing hydrocarbyl group which is a saturated straight chain or a saturated branched chain.
45. An oil-based well fluid as in Claim 41 wherein  $R^b$  in the mixture of bromine-containing diesters has a 2-butene moiety as the internal alkene moiety.
46. An oil-based well fluid as in any of Claims 41-45 wherein the bromine atoms in the mixture of bromine-containing diesters in which  $R^b$  contains an internal alkene moiety are bound to alkenyl carbon atoms.
47. An oil-based well fluid as in any of Claims 41-46 wherein the bromine-containing organic compound is 4-butyloctyl 2,3,4,5-tetrabromobenzoate; a mixture of bromine-containing esters comprising 2-butyloctyl 2,3,4,5-tetrabromobenzoate and di(2-butyloctyl) 3,4,5,6-tetrabromophthalate; and/or a mixture of diesters comprising (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(2-methylpropanoate), (2E)-2,3-dibromobut-2-ene-1,4-diyl bis(trichloroacetate), and (2E)-2,3-dibromo-4-[(trichloroacetyl)oxy]but-2-en-1-yl 2-methylpropanoate.
48. An oil-based well fluid as in any of Claims 1-11 which further comprises a bromine-containing organic compound containing two or more bromine atoms and having a bromine content of about 50 wt% or more, which bromine-containing organic compound is selected from
- a bromine-containing terminal alkene having three or more carbon atoms in the molecule
  - a bromine-containing internal alkene having four or more carbon atoms in the molecule;

- c) a tribromocumene mixture comprising 2,4,5-tribromocumene and one or more unsubstituted tribromobenzenes, wherein 2,4,5-tribromocumene is about 70 wt% or more relative to the total weight of the tribromocumene mixture, and the unsubstituted tribromobenzenes are about 5 wt% or more, relative to the total weight of the mixture;
- d) any two or more of the foregoing bromine-containing organic compounds.

49. An oil-based well fluid as in Claim 48 wherein the bromine-containing terminal alkene has three to about six carbon atoms in the molecule; the bromine-containing internal alkene has four to about eight carbon atoms in the molecule; the tribromocumene mixture has 2,4,5-tribromocumene in an amount of about 70 wt% to about 75 wt%, relative to the total weight of the tribromocumene mixture, and/or unsubstituted tribromobenzenes in an amount of 5 wt% to about 10 wt%, relative to the total weight of the tribromocumene mixture.

50. An oil-based well fluid as in Claim 49 wherein the bromine-containing terminal alkene has two or more bromine atoms bound to alkenyl carbon atoms; the bromine-containing internal alkene has two or more bromine atoms bound to alkenyl carbon atoms; the tribromocumene mixture contains as unsubstituted tribromobenzenes, 1,2,4-tribromobenzene in an amount of about 5 wt% or more, relative to the total weight of the tribromocumene mixture, and optionally 1,3,5-tribromobenzene, in an amount of about 0.75 wt% or more, relative to the total weight of the tribromocumene mixture.

51. An oil-based well fluid as in Claim 50 wherein the tribromocumene mixture contains 1,2,4-tribromobenzene in an amount of about 5 wt% to about 10 wt%, relative to the total weight of the tribromocumene mixture, and optionally 1,3,5-tribromobenzene, in an amount of about 0.75 wt% to about 1.5 wt%, relative to the total weight of the tribromocumene mixture.

52. An oil-based well fluid as in Claim 50 or 51 wherein the total amount is about 5 wt% to about 15 wt%, relative to the total weight of the relative to the total weight of the tribromocumene mixture.

53. An oil-based well fluid as in any of Claims 50-52 wherein 2,3,5-tribromocumene, 3,4,5-tribromocumene, and/or 2,3,4,5-tetrabromocumene are present in the tribromocumene

mixture, in a total amount of about 5 wt% or more, relative to the total weight of the relative to the total weight of the tribromocumene mixture.

54. An oil-based well fluid as in any of Claims 48-53 wherein the bromine-containing organic compound is 1,2-dibromo-1-hexene, 2,3-dibromo-2-butene, 2,3,4,5-tetrabromo-2,4-hexadiene, and/or a tribromocumene mixture having 2,4,5-tribromocumene in an amount of about 70 to about 73 wt%, 2,3,5-tribromocumene in an amount of about 3 wt% to about 5 wt%, 3,4,5-tribromocumene in an amount of about 1 wt% to about 2.5 wt%, 2,3,4,5-tetrabromocumene in an amount of about 7.5 wt% to about 9.5 wt%, 1,2,4,5-tetrabromobenzene in an amount of about 0.5 wt% to about 1.5 wt%, 1,2,4-tribromobenzene in an amount of about 6 wt% to about 8 wt%, and 1,3,5-tribromobenzene in an amount of about 1.25 wt% to about 2.5 wt%, all relative to the total weight of the tribromocumene mixture.

55. An oil-based well fluid as in any of Claims 1-54 wherein the well fluid is a drilling fluid, a packer fluid, a screen running fluid, a drill-in fluid, a completion fluid, or a workover fluid.

56. A method of treating a wellbore, said method comprising introducing into the wellbore a fluid as in any of Claims 1-55.

57. A method for minimizing or relieving a sustained casing pressure in an annulus of a wellbore, wherein the annulus contains a first fluid having a density, the method comprising introducing a second fluid into the annulus, wherein the second fluid has a density greater than the density of the first fluid and the second fluid is immiscible with the first fluid, characterized in that the second fluid comprises a halogen-containing sorbent, which sorbent comprises one or more halogens selected from fluorine, chlorine, bromine, and/or iodine, and one or more substrate materials.

58. A mixture comprising an oil and a halogen-containing sorbent comprising one or more halogens selected from fluorine, chlorine, bromine, and/or iodine, and one or more substrate materials, in which mixture there is about 0.1 to about 30 wt% halogen-containing sorbent.

59. A mixture as in Claim 58 in combination with a hydraulic fluid.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/037744

**A. CLASSIFICATION OF SUBJECT MATTER**IPC: **C09K 8/03** (2024.01); **B01J 20/04** (2024.01); **B01J 20/20** (2024.01); **C01D 3/10** (2024.01)CPC: **C09K 8/03**; **B01J 20/046**; **B01J 20/20**; **C01D 3/10**; **B01D 2257/602**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages              | Relevant to claim No. |
|-----------|-------------------------------------------------------------------------------------------------|-----------------------|
| Y         | CN 105536499 A (PETROCHINA CO. LTD.) 04 May 2016 (04.05.2016)<br>entire document                | 58, 59                |
| Y         | US 2021/0170332 A1 (MIDWEST ENERGY EMISSIONS CORP) 10 June 2021 (10.06.2021)<br>entire document | 58, 59                |
| A         | US 2016/0289527 A1 (ALBEMARLE CORPORATION) 06 October 2016 (06.10.2016)<br>entire document      | 1-4, 6, 7, 57-59      |
| A         | US 2013/0277063 A1 (PUMPWELL SOLUTIONS LTD.) 24 October 2013 (24.10.2013)<br>entire document    | 1-4, 6, 7, 57-59      |
| A         | US 2021/0139764 A1 (CHINA UNIVERSITY OF PETROLEUM) 13 May 2021 (13.05.2021)<br>entire document  | 1-4, 6, 7, 57-59      |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“D” document cited by the applicant in the international application

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

**13 September 2024 (13.09.2024)**

Date of mailing of the international search report

**24 September 2024 (24.09.2024)**

Name and mailing address of the ISA/US

**Mail Stop PCT, Attn: ISA/US**  
**Commissioner for Patents**  
**P.O. Box 1450, Alexandria, VA 22313-1450**

Facsimile No. **571-273-8300**

Authorized officer

**MATOS**  
**TAINA**

Telephone No. **571-272-4300**

# INTERNATIONAL SEARCH REPORT

International application No.

**PCT/US2024/037744**

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: **5, 8-56**  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).