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LIQUID GELLING AGENT FOR GASOLINE

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This invention relates to an agent for gelling gasoline or other liquid hydrocarbons to be used as a military incendiary in fire bombs, flamethrowers, etc. It consists of a suspension of certain aluminum soaps in a limited group of organic liquids. Since it can be handled as a liquid, it can be metered into a flowing stream of gasoline much more readily and accurately than can the conventional solid agents such as the aluminum soaps per se.

Moreover, we have found that the use of these suspensions greatly decreases the mixing time required in preparing the gasoline gel. An empirical standardized laboratory test exists for the determination of the "vortex time" of a given mixture which time is an indication of the length of time of mixing that will be required under field conditions as compared to that required for another mixture. Using solid aluminum di-2-ethyl hexoate, the "vortex time" at room temperature is about 20 minutes. When our suspensions are used the time is reduced to one to two minutes. This extreme reduction in time is a great advantage, particularly in the continuous preparation of gels using flow-line mixers.

We have found that a suitable suspension can be formed only if both the aluminum soap and the organic liquid are properly chosen. Because of the sensitivity of colloid systems to such characteristics as dielectric constants as well as the chemical relationships of the materials, most organic liquids are unsatisfactory. Usually they are either themselves gelled by the aluminum soap or else they adversely effect the properties of the gasoline gel. For example, while isopropyl alcohol is one of our preferred liquids, ethyl alcohol has an undesirable peptizing effect on the gasoline gel. The liquids which we have found satisfactory as the main suspending agent are: isopropanol, n-butanol, butyl acetate, ethylene glycol and hexylene glycol.

In addition, it is usually desirable to add an additional agent to aid in maintaining the soap in suspension. The added agent may be either one which increases the specific gravity of the liquid or one which increases the viscosity.

The suspension should be stable between −60° F. and 160° F. It must, of course, be miscible with gasoline or other hydrocarbon liquids.

We have found that only certain aluminum soaps are suitable for use in our compositions. In addition to being a good gelling agent for gasoline, it must be light and fluffy. Dense, amorphous soaps, such as "napalm," the well known mixture of fatty acid and naphthenic acid aluminum soaps, are not satisfactory. In general, the desired properties are found in soaps of single, rather than mixed, acids of 6 to 12 carbon atoms, e.g. aluminum di-hexoate, aluminum di-2-ethyl hexoate, and aluminum di-laurate. Of these soaps aluminum di-2-ethyl hexoate is greatly preferred because of its excellent gelling properties when mixed with the gasoline. The soap should be very fine, preferably less than 150 mesh size.

The method of forming the suspension is also important. If the aluminum soap is simply stirred into the liquid the suspension is unstable. The solids quickly settle out on standing and are difficult to redisperse. We have found that the soap and liquid should be blended

by a combined mixing and disintegration which gives a very thorough wetting of the soap particles. Suitable methods of dispersion are:

(*a*) Passing the mixture of soap and liquid thru a colloid mill;

(*b*) Mulling a paste of soap and liquid and then mixing the mulled paste with additional liquid;

(*c*) Subjecting the mixture of soap in suspension in the liquid to a violent combined disintegration and agitation, for instance in a container having at its bottom a propeller carrying shearing blades (e.g. a "Waring Blendor").

As auxiliary agents, ethyl cellulose is particularly desirable for increasing the viscosity. It has also been found to improve the gellation of the gasoline, permitting the use of smaller amounts of aluminum soap to produce a gel of a given viscosity. Carbon disulfide, ethylene dichloride and ethylene glycol are suitable for increasing the density of the liquid.

In general, the solid content of the suspension should lie between about 10 percent and 40 percent by weight. The upper limit is governed by the requirement that the suspension be sufficiently fluid to be handled as a liquid. On the other hand, too dilute a suspension will require the use of unduly large quantities, adding greatly to the expense. Furthermore, dilution of the gasoline with large quantities of non-gelling liquid adversely effects the gel.

The following examples illustrate this invention.

EXAMPLE 1

Suspensions in isopropanol

Aluminum di-2-ethyl hexoate, which is a light, fluffy powder, was suspended in isopropanol in various proportions. It was found that at 41 percent by weight the mixture was saturated and no longer flowable as a liquid. The most satisfactory suspensions contained from 25% to 35% soap. When mixed with gasoline, satisfactory gels were formed with from 3 to 5 percent soap by weight based on the gasoline. Laboratory experiments gave "vortex times" of from one to two minutes as compared to twenty minutes when the dry soap was added to the gasoline in the usual manner.

To determine the applicability to continuous mixing, a mixing nozzle was made from a standard 1 in. Y branch with the 45° outlet connected to a 1 in. flexible gasoline line. The vertical portion of the Y branch had a close nipple with a 1½ gal. funnel connected to it. A ½ in. nipple was inserted inside the close nipple and brazed. This device allowed the liquid thickener to flow directly into the middle of the gasoline stream. The lower end of the Y fitted into the hole of a 165 gal. range extending fuel tank, which is used as a fire bomb. The flexible hose was connected to a pump delivering gasoline. Full scale field tests were conducted using the nozzle and a 35 percent by weight suspension of aluminum di-2-ethyl hexoate at temperatures of about 85° to 90° F., using 3.5% by weight of soap, based on the gasoline. The result was a gel of good, homogeneous consistency. The field filling equipment using the solid soap as the thickener often gives a gel containing large lumps of coagulated semigelled soap.

While suspensions prepared simply by mixing the soap with isopropanol as described above are very satisfactory when freshly prepared, the soap settles out on long standing and is frequently difficult to redisperse, due to caking. Experiments were therefore conducted to remedy this defect. It was found that if the method of dispersion combined mixing with distintegration, improved results were secured. In each of the experiments, suspensions of 20 to 25 percent by weight aluminum di-2-ethyl hexoate and 75% to 80% by weight isopropanol were prepared. The following methods were successful.

(*a*) Passing the mixture of soap and isopropanol through colloid mill three times with fineness settings of 10, 8, and 5 microns, respectfully.

(*b*) Mulling a paste of soap and isopropanol and then adding additional isopropanol.

(*c*) Subjecting the suspension to a violent combined vertical and horizontal circulation, mixing, and disintegrating action in a receptacle having at its bottom a propeller and disintegator including cutting blades. (On a laboratory scale the device known as a "Waring Blendor" was employed.)

EXAMPLE 2

Isopropanol plus ethyl cellulose

The addition of small proportions of ethyl cellulose to the isopropanol suspensions of aluminum di-2-ethyl hexoate was found to materially increase the effectiveness of the composition in gelling gasoline. The amount of ethyl cellulose ranged from 1 to 2.5 percent by weight of the suspension. A preferred composition is:

	Percent
Isopropanol	86.0
Aluminum soap	12.5
Ethyl cellulose	1.5

The percentages are by weight. The aluminum soap was aluminum di-2-ethyl hexoate. The ethyl cellulose was 47.3% ethoxyl, 88 cp. visocosity (Hercules Powder Co. N–100). Using this composition it was found that only half as much aluminum soap was required for gellation as when the isopropanol was used alone as the suspending agent or when the dry soap was added directly to the gasoline. Two percent soap based on the gasoline in the presence of ethyl cellulose gave results at least equal to those obtained with 4 percent soap in each of the other cases.

The ethyl cellulose also reduces the setting rate of the soap by increasing the viscosity of the liquid and increases the ease of dispersion after long storage at normal temperatures. On storage at very low temperatures, e.g. −40° F., the liquid sets to a gelatinous mass. It becomes fluid, however, on rewarming to room temperatures and the soap can then be redispersed by vigorous shaking.

The settling properties of the solutions containing ethyl cellulose were improved when treated in a colloid mill in the same manner as suspensions in isopropanol alone.

EXAMPLE 3

Isopropanol plus heavier liquids

In order to reduce the rate of settling of the soap and increase the case of redispersion, heavier liquids were added to the isopropanol. Suspensions of aluminum di-2-ethyl hexoate which were satisfactory were:

17% soap by weight in—
31.2% isopropanol by volume
68.8% ethylene dichloride
(Sp. gr. 1.12)

25% soap in—
70% isopropanol
30% ethylene glycol
(Sp. gr. 0.88)

25% soap in—
70% isoporpanol
30% carbon disulfide
(Sp. gr. 0.92)

30% soap in—
50% isopropanol
50% nitrobenzene
(Sp. gr. 0.99)

These suspensions were satisfactory gelling agents for gasoline. In the first suspension, having a specific gravity of 1.12, practically no settling occurred. In each of the other cases settling was slower than in isopropanol alone and redispersion was easier. Although the first mixture is relatively low in soap on a weight basis it contains substantially the same amount on a volume basis as a 25% by weight dispersion of soap in isopropanol.

EXAMPLE 4

Suspensions in butyl acetate

Butyl acetate was also found to be a suitable liquid for foming the suspensions. Compositions containing 20 percent aluminum di-2-ethyl hexoate and 80 percent butyl acetate by weight had satisfactory properties. As is the case with isopropanol, improved results as to settling and remixing are obtained if the suspension is prepared by mulling, subjection to a violent agitation-disintegration, or passage through a colloid mill.

EXAMPLE 5

Butyl acetate plus chlorinated hydrocarbons

In an effort to improve the settling properties, higher density liquids were prepared by mixing the butyl acetate with various chlorinated hydrocarbons, e.g. carbon tetrachloride, tetrachloroethanol, methylene chloride and ethylene chloride. It was found that at twenty percent soap those dispersions containing ethylene chloride were more fluid than those with other chlorinated hydrocarbons. It was further found that when the proportions were 37.5% butyl acetate, 62.5% ethylene chloride (by volume) giving a specific gravity of 1.12, settling out was negligible.

A suspension of 16% by weight aluminum di-2-ethyl hexoate in this solvent blend showed good gelling properties for gasoline, causing gellation in less than two minutes. Flow properties of this suspension were rated excellent at −40° F. and fair (pourable) at −58° F.

EXAMPLE 6

Butanol plus ethylene chloride

Another mixture of specific gravity 1.12 that has proven satisfactory is n-butanol, 31.7% by volume ethylene dichloride 68.3%. A suspension of 16% by weight aluminum di-2-ethyl hexoate and 84% of this liquid blend is suitable.

Thus, while ethylene chloride alone is not a suitable suspending liquid, it forms in admixture with isopropanol, butyl acetate and n-butanol very desirable high density suspending liquids.

EXAMPLE 7

Ethylene glycol-hexylene glycol

A suspension of 25% by weight aluminum di-2-ethyl hexoate and 75% by weight of a mixture of 50% ethylene glycol and 50% hexylene glycol was found to be satisfactory.

While we have given a number of detailed examples, it will be understood that further variations are possible. We therefore wish our invention to be limited solely by the scope of the appended claims.

We claim:

1. A composition for gelling hydrocarbons consisting essentially of a suspension of an aluminum salt of a single fatty acid containing from 6 to 12 carbon atoms in a liquid selected from the group consisting of: isopropanol, butyl acetate, isopropanol containing from one to 2.5 percent ethyl cellulose, mixtures of isopropanol and ethylene chloride, mixtures of isopropanol and ethylene glycol, mixtures of isopropanol and carbon disulfide, mixtures of isopropanol and nitrobenzene, mixtures of butyl acetate and ethylene chloride, mixtures of n-butanol and ethylene chloride, and mixtures of ethylene glycol and hexylene glycol, each of the components of each of said mixtures being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

2. A composition for gelling gasoline consisting essentially of a suspension of aluminum di-2-ethyl hexoate in isopropanol, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

3. A composition for gelling gasoline consisting essentially of a suspension of aluminum di-2-ethyl hexoate in isopropanol containing from one to 2.5 percent ethyl cellulose, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

4. A composition for gelling gasoline consisting essentially of a suspension of aluminum di-2-ethyl hexoate in a mixture of isopropanol and ethylene chloride, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

5. A composition for gelling gasoline consisting essentially of a suspension of aluminum di-2-ethyl hexoate in a mixture of isopropanol and ethylene glycol, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

6. A composition for gelling gasoline consisting essentially of a suspension of aluminum di-2-ethyl hexoate in a mixture of isopropanol and nitrobenzene, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

7. A composition for gelling hydrocarbons consisting essentially of a suspension of aluminum di-2-ethyl hexoate in a mixture of isopropanol and carbon disulfide, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

8. A composition for gelling hydrocarbons consisting essentially of a suspension of aluminum di-2-ethyl hexoate in butyl acetate, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

9. A composition for gelling gasoline consisting essentially of a suspension of aluminum di-2-ethyl hexoate in a mixture of butyl acetate and ethylene chloride, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

10. A composition for gelling gasoline consisting essentially of a suspension of aluminum di-2-ethyl hexoate in a mixture of n-butanol and ethylene chloride, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

11. A composition for gelling gasoline consisting essentially of a suspension of aluminum di-2-ethyl hexoate in a mixture of ethylene glycol and hexylene glycol, each of the components of said mixture being present in substantial proportions, such that the solid content of said composition lies in the range 10–40 percent by weight.

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