The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment to us of any royalty thereon.

This invention relates to incendiary fuels, to thickening agents therefor and to ways and means whereby stability, uniformity and consistency of these products may be improved.

More particularly this invention relates to the improvement of the stability, consistency and over-all performance of known incendiary gels and thickeners therefor by the addition of alumina aerogel thereto.

During the last war, sources of rubber were cut off and the rubber, required to thicken or gel gasoline and similar liquid hydrocarbon fuels to produce incendiary gels of many military uses, was not available. It became necessary to resort to other types of gelling agents. A satisfactory class of thickeners were developed, which would produce the desired consistencies of incendiary fuel gel.

The desired consistency, of course, varies according to the manner in which the incendiary gel is to be employed. For instance, a higher viscosity is generally desired for shell and hand grenade fillings than for flame thrower fillings wherein the incendiary must be projected under pressure through a nozzle and hurled through the air for a substantial distance in the form of a stream. As the result of much experience and experimentation it has been found desirable, and at times necessary, to impart controllable consistencies to the fuel gel to be used, depending upon the manner of contemplated use.

A class of soap thickeners have been developed which have been used successfully in the gelling of gasoline, kerosene or other liquid hydrocarbon fuel for incendiary use. The more successful thickening agents of this class of soaps are aluminum soaps of fatty acids and particularly coprecipitated aluminum soaps of mixed acids such as mixtures of coconut acids and naphthenic acid, as well as mixtures containing oleic acid. Fieser U. S. Patent No. 2,606,107 and Minich U. S. Patent No. 2,390,609, exemplify this class of soap thickeners for gasoline and other liquid hydrocarbon fuels. The popular name for a thickener of this type is "napalm." Unfortunately this class of thickening agents and the gels formed therewith, are not ideal in that they do not have the desired stability as to their consistency, particularly when in contact with chemical agents. The gels tend to liquefy or "separate out" on slight increases in their moisture content, to thicken when chilled and to become more mobile when heated. It has also developed that these thickeners, and the incendiary gels derived therefrom, are not sufficiently resistant to the deleterious effects of xylenol, amines, potassium acetate, acid soldering flux and other substances to which they are, at times exposed during the processes of compounding, and the storage and preparation for use in the field. It has also been found that free fatty acids contained in the napalm thickeners tend to peptize the mixture.

Many attempts have been made, heretofore, to stabilize these incendiary compositions with additives, heat and chemical treatments. Among other things, a large number of well-known dehydrating crystals and granules have been tried out in various ways, but in each case the dehydrating agent used introduced new difficulties. Magnesium sulfate formed hard scales and flakes, broke down the gel and was exceedingly slow in reaching an equilibrium in the composition. Other dehydrating agents proved less effective. None of the crystal and granular dehydrating agents would maintain the desired consistency under both arctic and tropical temperature conditions which vary from -40° to 125°F. Further, none of these agents would maintain the required consistency in the presence of the chemical agents above which tend to deteriorate the gel.

Many of the difficulties encountered in the use of napalm thickeners have been overcome by the use of a silica gel additive as proposed by Bauer and Broughton, U. S. application Serial No. 765,644; the use thereof tends to prevent the breakdown of fuel gels when they are subjected to exploded powder gels or to the deleterious effects of alcohols, phenols, amines, potassium acetate, soldering flux and various rust preventative with which the gels become physically associated during production, storage, and use. The silica gel, however, does not react with any free fatty acids contained in the napalm thickener and does not remove this peptizing material.

It is, therefore, the object of our invention to improve the known incendiary gels which include thickeners of the napalm type to obtain a stabilized consistency.

It is an object to provide thickeners having stabilized consistency, particularly in the presence of moisture and deleterious chemical agents.

It is a further object to provide means and a process whereby the consistency of incendiary fuel gels and thickening agents therefor may be increased and stabilized against chemical agents.

It is a further object to improve the process whereby napalm thickeners are produced.

It is a particular object to increase the consistency and to improve the chemical stability of incendiary gels, and thickeners therefor, beyond that which is obtained by the addition of silica gel thereto.

We have found that alumina aerogel is a superior additive to napalm thickeners. This material when added with napalm to gasoline, kerosene or other liquid hydrocarbon fuels causes a marked, and unexpected, increase in the consistency and stability of the resultant gels. In addition, the alumina aerogel is an effective grinding aid and anti-agglomerant in the preparation of finely ground napalm powder. Napalm powder ground with alumina aerogel exhibits thickening in liquid hydrocarbon fuels, superior to napalm powder alone as well as to napalm powder ground with silica gel.

In the proposal to improve the gel consistency of napalm thickened liquid hydrocarbon fuels by the addition of silica gel, it is believed that the action of the silica gel is mechanical in nature. Alumina aerogel, on the other hand, not only possesses mechanical absorbent activity but also is capable of reacting chemically with the free fatty acids contained in the napalm thickeners to remove this peptizing material and, at the same time, to create additional aluminum soap which adds its thickening power to that of the original napalm. The alumina aerogel is also believed to improve the thickening power by contributing additional aluminum to the gel linkages thereby increasing the chain lengths in the gel structure. While we are not to be bound by this theory as to the unexpected improvement exhibited by the use of alumina aerogel, its outstanding action is readily demonstrated.
Its action in improving the thickening power of napalm, while also serving as a grinding aid and anti-agglomerant, is unique. While the alumina gel may be introduced into the thickened fuel in many ways, the following two procedures have been employed effectively:

1. By first adding the alumina powder to the napalm powder and grinding the mixture in standard equipment, such as a ball mill, to obtain an intimate blend. Then adding the blend to a liquid hydrocarbon fuel to obtain a gel.

2. By first forming a suspension of the alumina in the liquid hydrocarbon fuel, followed by addition of the napalm powder to the suspension to obtain a gel.

Procedure 1 above is preferred since the advantageous, unexpected properties of the alumina gel as a grinding aid and anti-agglomerant are thus utilized to the fullest extent.

Our invention can be applied to all soap thickeners to be used to gel liquid hydrocarbon fuels but we have found that the addition of alumina gel is most beneficial with aluminum soaps of fatty acids and particularly with napalm thickener. Napalm is generally considered to embrace the acid mixture and the aluminum salt mixture of fatty acids found in coconut oil together with approximately an equal amount of one or more of the following compounds; unsaturated fatty acids having from 17 to 22 carbon atoms such as oleic and linoleic acids, and naphthenic acid. One such composition is the aluminum salts of the acids in the following proportions:

Coconut fatty acids .................................. 50
Oleic acid ........................................... 25
Naphthenic acid ...................................... 25

It may be stabilized against oxidation by the addition of alpha-naphthol to the sodium soap used to prepare the aluminum soap. It is described more fully in Joint Army-Navy Specification JAN-N-589, April 30, 1948. The alumina aerogel may be added to the soap thickener within the range of 0.5 to 25% by weight of the soap to 99.5 to 75% by weight of the soap. In the preferred embodiment, 5% by weight of alumina aerogel is employed with 95% by weight of napalm to form a thickener for gasoline. The thickener may be added to the gasoline fuel in varying percentages, from 6 to 12% by weight being the normal range.

The preferred method for the preparation of our improved incendiary fuel gel is set forth in the example below which is presented by way of illustration and not of limitation.

**Example**

95 grams of napalm (conforming to Joint Army-Navy Specification JAN-N-589, produced by the Imperial Paper and Color Corporation) and 5 grams of aluminum aerogel (produced by the process of Kistler—J. Phys. Chem., vol. 36 (1932), page 52, from aluminum hydroxide) were placed in a ball mill and ground together to form a powder mixture containing 5% by weight of aerogel and 95% by weight of napalm. A 15 gram portion of the powder thus formed was then added to 225 grams of test gasoline in a vessel. The vessel was closed tightly and shaken vigorously until no further settling of particles was observed. The vessel was then agitated for an additional period equal to the time required to overcome settling. The gel was then stored.

The test gasoline used in this example is a synthetic blend of hydrocarbons which has a composition similar to the gasolines used in the production of incendiary fuel gels. This blend has properties, for gelation purposes, very closely approximating those of ordinary gasoline but is used in place thereof because it can be exactly dupli-

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It is apparent that alumina-modified napalm thickener is far superior to silica-modified thickener. This superiority in fuel gel consistency, coupled with its stability, toward moisture and the chemical agents encountered in processing, storage and use, and with the ability to neutralize free fatty acids in napalm definitely establishes alumina aerogel as an outstanding additive for napalm thickeners. The improvement in grinding characteristics of napalm containing alumina is also of great benefit in the processing of the thickener.

We claim:

1. In the production of an incendiary liquid hydrocarbon fuel gel thickened with an aluminum soap thickener, the improvement which comprises the inclusion therein of alumina aerogel in the proportion of 0.5 to 25 parts by weight of alumina gel, to 99.5 to 75 parts by weight of the soap thickener to stabilize the thickened fuel gel toward the deleterious action of chemical agents.

2. In the production of a thickened incendiary fuel gel comprising essentially a coprecipitated aluminum soap of mixed naphthenic acid, oleic acid and coconut fatty acids and gasoline, the improvement which comprises the inclusion of about 0.3% by weight of alumina aerogel to stabilize the thickened fuel gel toward the deleterious action of chemical agents.

3. A thickener for incendiary liquid hydrocarbon fuel gels consisting essentially of an aluminum soap thickener containing between 0.5 to 25% by weight of alumina aerogel.

4. A thickener for gasoline consisting essentially of a coprecipitated aluminum soap of mixed naphthenic acid, oleic and coconut fatty acids and about 5% by weight of alumina aerogel.

5. The process for preparing an improved stabilized thickener for liquid hydrocarbon fuels which comprises grinding an aluminum soap thickener with between 0.5 and 25% by weight of alumina aerogel until an intimate blend is obtained.

6. The process of claim 5 wherein the soap thickener is a coprecipitated aluminum soap of mixed naphthenic acid, oleic acid and coconut fatty acids.
7. The process of claim 6 wherein the weight of the alumina aerogel is about 5% by weight of the soap thickener.

8. The process for thickening liquid hydrocarbon fuels which comprises grinding an aluminum soap thickener with between 0.5 and 25% by weight of alumina aerogel until an intimate blend is obtained, adding said blend to a liquid hydrocarbon fuel and agitating until a gel is formed.

9. The process of claim 8 wherein the soap thickener is a coprecipitated aluminum soap of mixed naphthenic acid, oleic acid and coconut fatty acids.

10. The process of claim 9 wherein the weight of the alumina aerogel is about 5% of the weight of the soap thickener.

References Cited in the file of this patent

UNITED STATES PATENTS

2,606,107 Fieser ---------------- Aug. 5, 1952
2,625,508 Stross ---------------- Jan. 13, 1953