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3,795,556

GELLED GASOLINE INCENDIARY COMPOSITIONS CONTAINING TRIETHYL ALUMINUM AND A METAL

Nathan J. Sippel, China Lake, and Richard K. Young, San Jose, Calif., assignors to the United States of America as represented by the Secretary of the Navy No Drawing, Filed Apr. 23, 1964, Ser. No. 363,675

Int. Cl. C10I 7/00

U.S. Cl. 149—109

9 Claims

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

The present invention relates to improved incendiary compositions and to the method of preparation.

The most commonly used self-igniting (pyrophoric) incendiary material is white phosphorus. At normal temperatures it is a solid so that its uses are more or less limited. Its low melting point sometimes results in melting on storage and if used in munitions, this will cause a shift in the center of gravity and result in flight instability. White phosphorus will not ignite in water. Although it will ignite in air, on hitting water, it will extinguish and sink because of its density. This, of course, limits its use over water. Another common incendiary material is napalm-gasoline; however, it is not self-igniting. Napalm is an aluminum soap comprising a mixture of oleic, naphthenic and coconut fatty acids which makes gasoline thicken or gell. The present invention is for self-igniting compositions which are an improvement over such materials now used and which will overcome many of the critical problems encountered in attaining maximum incendiary effects.

It is therefore an object of the present invention to provide a composition with physical properties which make it easy to incorporate in simple incendiary devices.

Another object is to provide a composition which will normally ignite over water thereby increasing the tactical uses in military weapons.

A further object is to provide an improved composition for use in flame throwers and other instruments in which liquid flow is a requirement.

Still another object is to provide a method of modifying self-igniting compositions so that handling safety is increased.

Yet another object of the present invention is to provide a self-igniting composition with reduced toxicity level.

A still further object is to provide a composition with improved chemical and physical properties such that consistent ignition results.

Another object of the present invention is to provide a composition with improved incendiary characteristics, e.g., ability to stick to the target, increased burning time, and better dispersion on the target.

Yet another object of this invention is to provide an improved incendiary composition which will ignite on impact and will not leak from its container.

Other objects, features, and many of the attendant advantages of this invention will become readily appreciated as the same become better understood by reference to the following detailed description.

For purposes of this invention "pyrophoric composition" refers to a material capable of undergoing instantaneous ignition either (a) upon contact with oxygen containing substances, such as air, or (b) upon impact, such as metals or alloys which produce sparks on gentle friction.

In accordance with this invention a series of incendiary compositions which are self-igniting (pyrophoric) are de-

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scribed. These compositions will normally ignite over water. Self ignition is accomplished by exposure to air or other oxygen-bearing material. They can also be modified to obtain ignition on contact with a target due to the force of impact. These incendiary compositions comprise (1) organic-metallic compounds such as triethylaluminum (TEA), trimethyl aluminum, tri-n-propyl aluminum, triisobutyl aluminum, diethyl aluminum chloride, ethyl aluminum dichloride, ethyl aluminum sesquichloride, triethylborane, diethylzinc; (2) liquid hydrocarbon fuels and their mixtures as extending agents, such as motor gasoline, aviation gasoline, JP-4 jet fuel, and JP-5 jet fuel; and (3) gelling agents such as dry silicone dioxide, activated carbon, activated alumina, anhydrous calcium sulfate, colloidal sulfur, polyisobutylene (Vistanex), and pyrogenic silica (Cab-O-Sil). Metal additives were also added to modify the present compositions whereby desirable incendiary properties were obtained. These additives include magnesium, aluminum, boron, zirconium, silicon and titanium.

The jet fuel, JP-4, used herein consists essentially of about 65% gasoline and 35% light petroleum distillate. The military jet fuel, JP-5, also used in this invention is a specially refined kerosine which has a flash point of 140° F. and a freezing point of -40° C.

One of the gelling agents which was used in a polyisobutylene sold under the trademark, "Vistanex"; another gelling agent also used herein is a pyrogenic silica (silicon dioxide of .015μ particle size) sold under the trademark, "Cab-O-Sil."

The novel products of this invention and the process for their manufacture will be more completely understood by reference to the following examples wherein all percentages are by weight.

EXAMPLE I

Ingredients:	Percent by weight
Triethylaluminum -----	48.6
Gasoline (regular motor) -----	48.6
Silicon dioxide -----	2.8

The above ingredients were mixed in a dry box containing a purified nitrogen atmosphere (a container free from oxygen and moisture because of the pyrophoric nature of these compositions). Only the silicon dioxide was dried before being placed into the dry box. Triethylaluminum was added to the gasoline and then the silicon dioxide. Gel formation after mixing was immediate. The gel was then loaded into an airtight test gun. The test gun was then removed from the dry box and the gel successfully ejected and ignited.

EXAMPLE II

Ingredients:	Percent by weight
Triethylaluminum -----	39
Gasoline (regular motor) -----	58.5
Silicon dioxide -----	2.5

The above ingredients were mixed together by the same procedure described in Example I.

EXAMPLE III

Ingredients:	Percent by weight
Triethylaluminum -----	57.4
Gasoline (aviation) -----	38.3
Silicon dioxide -----	4.3

These ingredients were also processed in the same manner as hereinbefore described.

EXAMPLE IV

Ingredients:	Percent by weight
Triethylaluminum -----	47.4
JP-4 -----	47.4
Silicon dioxide -----	5.2

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EXAMPLE V

Ingredients:	Percent by weight
Triethylaluminum	57.1
JP-5	38.1
Silicon dioxide	4.8

All of the above ingredients were blended together by the same method described in Example I herein. The composition of Example V will ignite on target impact. As a general rule higher concentrations of triethylaluminum will ignite in air and lower concentrations will not ignite.

EXAMPLE VI

Ingredients:	Percent by weight
Triethylaluminum	58.3
Gasoline (regular motor)	19.4
Magnesium (44 μ particle size)	19.4
Silicon dioxide	2.9

Metal additives were added to the ingredients disclosed in Examples I-V to obtain desirable incendiary properties. The materials were processed in the same manner as described in Example I, with the addition of the dry magnesium along with the silicon dioxide.

EXAMPLE VII

Ingredients:	Percent by weight
Triethylaluminum	58.3
Gasoline (regular motor)	19.4
Aluminum (5 μ particle size)	19.4
Silicon dioxide	2.9

Mixing procedure same as described above.

EXAMPLE VIII

Ingredients:	Percent by weight
Triethylaluminum	58.6
Gasoline (regular motor)	19.6
Boron (1 μ particle size)	19.6
Silicon dioxide	2.2

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the triethylaluminum was added along with the silicon dioxide (Cab-O-Sil). This composition made a flame on impact and some black smoke was given off from the rubber compound.

EXAMPLE X

Ingredients:	Percent by weight
Triethylaluminum	40
Gasoline (regular motor)	52
Vistanex (L-140 viscosity)	8

Again this formulation was processed in accordance with the procedure described in Example IX above. The Vistanex used was L-140 viscosity. However, it is available in a variety of varying viscosities which are classified according to their molecular ranges, and is used to extend the distance to which pyrophoric materials can be ejected. The above composition ignited on impact with the ground. Little gel globs ranging in size from a dime to a quarter were scattered from 55 to 100 feet and would burn and smolder.

Many samples of pyrophoric formulations were made up with Vistanex as the gelling or thickening agent and no deterioration or liquid separation was noted. With powdered metal additives incorporated to improve the incendiary characteristics there was little or no settling out of the metal.

The following table is a summary of the flame tests performed on a number of incendiary formulations, the majority of which utilized Vistanex (polyisobutylene) as the gelling agent. A test gun was used which would eject thickened fuels at 350 p.s.i. for distances of up to 200 feet. The test gun comprises a sealed 2 inches I.D. aluminum tube about eight inches long having a quarter inch stainless tubing nozzle seven inches long. Nitrogen was the propelling agent by actuating a teflon piston contained in the tube. An aluminum foil burst disc located at the nozzle would break at the ejection pressure.

TABLE I.—FLAME TESTS

Number	Composition, percent				Remarks
	Self-igniting compound	Extending agent	Gelling agent	Other additives	
1.....	TEA, 60	Gasoline, 33.....	Cab-O-Sil, 7.....		Flame at 20 feet, flame travel 62 feet.
2.....	TEA, 59.3	Gasoline, 19.3.....	Cab-O-Sil, 4.5, Kel-F, 2.4, Bentone, 0.9.	Al (5 μ), 13.6	Flame, gel travel 80 feet. Burst into flame in air near test gun.
3.....	TEA, 38.9	Gasoline, 53.4.....	Vistanex, 4.9, Cab-O-Sil, 2.8.		Flame upon impact with ground. Gel travel 90 feet. Gel splatter 65 to 80 feet no visible flame in air, only a white smoke streamer.
4.....	TEA, 40	Gasoline, 52.....	Vistanex, 8.....		Flame on impact, Travel 101 feet. No visible flame in air, some white smoke visible at 55 feet. Gel globs from the size of a dime to a quarter would burn and smolder.
5.....	TEA, 40	Gasoline, 50.....	do.....		Flame on impact with ground. Travel 104 feet. Gel scatter 60 to 104 feet. No visible flame in air, only white smoke.
6.....	TEA, 43.5	Gasoline, 43.5.....	Vistanex, 8.2, Cab-O-Sil, 4.8.		Flame on impact. No visible flame in air, good flame on ground. Travel 62 feet. Some black smoke.
7.....	TEA, 60	Gasoline, 20.....	Vistanex, 8.....	Zr (20 μ)	Flame. Some flame in air at 70 feet. Fire on impact with ground. Travel 82 feet. When stirred gel glob which appeared dead, burst into flame.
8.....	TEA, 60	do.....	do.....	Al (100 μ) 12	No ignition. Travel 16 feet. Too viscous. Stirred gel burst into flame.

Terms defined:
TEA=triethylaluminum
Vistanex=polyisobutylene (trade name)
Cab-O-Sil=silica pigment (trade name)
Zr=zirconium
Al=aluminum
Gasoline=regular motor

This formulation gave a high heat of combustion.

EXAMPLE IX

Ingredients:	Percent by weight
Triethylaluminum	40
Gasoline (regular motor)	50
Polyisobutylene (Vistanex)	8
Silicon dioxide (Cab-O-Sil)	2

The Vistanex, which is a rubbery compound consisting of a paraffinic hydrocarbon polymer polyisobutylene, was first dissolved in the hydrocarbon solvent, gasoline, then

Using the same test gun, the following comparisons can be made for flame thrower operations:

	Feet
6% M2 napalm and gasoline travel range	135
8% Vistanex L-140 and gasoline containing 50% TEA	105

Nearly all of the pyrophoric compositions using Vistanex as the thickener showed no flame until impact which may advance this product for use in anti-personnel devices.

The usefulness of triethylaluminum mixed with hydrocarbon fuels has been demonstrated. Two main features are self-ignition and ignition on contact with a target, and both features are dependent upon the composition. Its application to incendiary weapons, such as flame throwers, is dependent upon the gelling or thickening agent used. Napalm is one of the best gelling agents for hydrocarbon fuels, however, it is incompatible with triethylaluminum.

Small scale spell tests with 10 gram liquid mixtures of triethylaluminum and hydrocarbon fuels indicate that for positive self-ignition the percentage of triethylaluminum required is the same as for the gelled or thickened mixtures. No ignition was obtained with the following weight percent of non-gelled or non-thickened hydrocarbon fuel mixture:

(a).....	{JP-5, percent.....	50	} No ignition.
	{Triethylaluminum, percent.....	50	
(b).....	{Gasoline (motor), percent.....	65	} Do.
	{Triethylaluminum.....	35	
(c).....	{Gasoline (white), percent.....	60	} Do.
	{Triethylaluminum, percent.....	40	

A considerable amount of heat was given off during the reaction as was evidenced by the apparent boiling of the liquid and the dense white fumes given off. Portions of the polyethylene containers melted. (Polyethylene melts at about 230° F.).

In order to get self-ignition in gelled or thickened hydrocarbon fuels from 40 to 60 percent triethylaluminum is required. Mixtures of 60% motor gasoline and 40% triethylaluminum or 40% JP-5 and 60% triethylaluminum ignited when fired from the test gun.

The amount of thickening or gelling agent used may be limited in accordance with the expected use of the composition; e.g., fire bombs could be thinner or flowable, whereas, material for a flame thrower type device could be thicker since ejection distance is important. Applicants found that up to about ten percent by weight thickener or gelling agent was the essential range for this invention. Too much thickener, such as Cab-O-Sil, destroys the gel structure and makes the material granular.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A pyrophoric composition comprising a mixture of
 - (a) an organic-metallic self-igniting compound;
 - (b) an extending agent; and
 - (c) a gelling agent.

said compound being a member selected from the group consisting of triethylaluminum, trimethylaluminum, tri-n-propyl aluminum, tri-isobutyl aluminum, diethyl aluminum chloride, ethyl aluminum dichloride, ethyl aluminum sesquichloride, methyl aluminum sesquichloride, triethylborane and diethylzinc; and mixtures thereof;

said extending agent being a member selected from the group of liquid hydrocarbon fuels consisting of motor gasoline, aviation gasoline, jet fuel, jet kerosine and mixtures thereof; and

said gelling agent being a member selected from the group consisting of silicon dioxide, activated

carbon, calcium sulfate, colloidal sulfur, polyisobutylene and mixtures thereof.

2. A pyrophoric formulation consisting essentially of the following ingredients:

triethylaluminum
gasoline, and
silicon dioxide.

3. A pyrophoric formulation consisting essentially of the following ingredients:

triethylaluminum
gasoline
magnesium, and
silicon dioxide.

4. A pyrophoric formulation consisting essentially of the following ingredients:

triethylaluminum
gasoline
polyisobutylene, and
silicon dioxide.

5. A pyrophoric formulation consisting essentially of the following ingredients:

triethylaluminum
gasoline, and
polyisobutylene.

6. A pyrophoric formulation consisting essentially of the following ingredients:

triethylaluminum
gasoline
polyisobutylene, and
zirconium.

7. A pyrophoric formulation consisting of the following ingredients:

triethylaluminum
gasoline
polyisobutylene, and
aluminum.

8. A pyrophoric composition consisting essentially of the following ingredients:

Ingredients:	Percent by weight
Triethylaluminum	40 to 60.
Gasoline	20 to 50.
Polyisobutylene	Up to 10.

9. A pyrophoric acomposition consisting essentially of the following ingredients:

Ingredients:	Percent by weight
Triethylaluminum	40 to 60.
Gasoline	20 to 50.
Aluminum	10 to 20.
Polyisobutylene	Up to 10.

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BENJAMIN R. PADGETT, Primary Examiner

U.S. Cl. X.R.

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