United States Patent Office 3,732,131
Patented May 8, 1973

3,732,131

GUN PROPELLANT CONTAINING NITROPLASTICIZED NITROCELLULOSE AND TRIAMINOGUANIDINE NITRATE

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No Drawing. Filed Oct. 14, 1971, Ser. No. 192,718
Int. Cl. C06d 5/06
U.S. Cl. 149—18 9 Claims

ABSTRACT OF THE DISCLOSURE

Non-metallized gun propellant systems are provided containing triaminoguanidine nitrate oxidizer alone or in combination with other oxidizers such as cyclotrimethylene trinitramine or cyclotetramethylene tetranitramine. The binder system is based on nitrocellulose and is typically a highly nitroplasticized nitrocellulose binder system.

BACKGROUND OF THE INVENTION

This invention relates to "gun propellants" which are generically defined herein as propellants for propelling projectiles. Specifically, this invention is concerned with gun propellants containing triaminoguanidine nitrate oxidizer alone or in combination with other oxidizers such as cyclotrimethylene trinitramine or cyclotetramethylene tetranitramine.

Gun propellants are referred to as low explosives to distinguish them from detonating high explosives and differ from high explosives in that the rate of energy release by autocombustion is controlled within certain limitations. The first real gun propellant was made from potassium nitrate, sulfur charcoal and was referred to as black powder. Nitrocellulose forms the basis for all modern gunpowders and is typically combined today with nitroglycerine to form a smokeless powder. "Smokeless powder" refers to colloided nitrocellulose either alone or in admixture with nitroglycerine or other materials. Smokeless powders are not in reality powders in the common sense of the word, nor are they smokeless, except when compared with black powder. Modern powders may take many forms including flakes, strips, pellets and cylinders. However, the cylindrical grain is most commonly employed for military purposes. "Single-base powders" generally refer to colloided nitrocellulose in the absence of nitroglycerine or other plasticizer. The terminology "double-base powder" generally refers to powders containing nitrocellulose and nitroglycerine or other plasticizer. These double-base powders usually contain from 15 to 40% nitroglycerin. Although double-base powders have many desirable characteristics, they also have many undesirable performance features including a high burning temperature which causes excessive barrel erosion when compared with single-base powders. Additionally, nitroglycerine is hazardous to handle.

Since the beginning of the twentieth century, the fundamental nature of solid propellant compositions used in small arms ammunition and the like has remained substantially unchanged. While improvements have been made, such as the introduction of ball propellant, cool burning extruded compositions, and the utilization of deterrents and geometries to improve control of gas evolution, the formulatoins are still based primarily upon nitrocellulose with or without nitroglycerine as indicated above.

The early single-base gun propellant, utilizing nitrocellulose with 13.15% nitrogen content, has a mass impetus of 357,000 ft.-lbs./lb. and an isochoric flame temperature of 3292° K. Incorporation of 20 weight percent of nitroglycerin gives the standard double-base propellant with a mass impetus of 378,000 ft.-lbs./lb. and an isochoric flame

temperature of 3592° K. As mentioned previously, the high flame temperature of the double-base system is very undesirable since it severely limits the barrel life of the gun due to barrel erosion. To overcome this critical problem, triple-base gun propellants were developed in which nitroguanidine was incorporated as a coolant into the nitrocellulose-nitroglycerine system. Representative conventional triple base propellants are the M30 (impetus=364,000 ft.-lbs./lb., T_v=3040° K.) and the M31

(impetus=335,000 ft.-lbs./lb., T_v=2597° K.)

It is readily apparent, however, that the required reduction in flame temperature is accomplished by a severe degradation in mass impetus. It would be highly desirable, therefore, to combine the high impetus of the double base system and the low flame temperature of the triple-base system.

SUMMARY OF THE INVENTION

It has now been discovered that improved nitrocellulose-based gun propellants can be formulated using triaminoguanidine nitrate as the oxidizer. Secondary oxidizers such as cyclotrimethylene trinitramine and cyclotetramethylene tetranitramine can be added to the propellant composition if desired. A highly nitroplasticized nitrocellulose binder system is preferably employed. For example, a high mass impetus system of this type has been developed with a mass impetus above 400,000 ft.-lbs./lb. and with an isochoric flame temperature below 3000° K. The present gun propellant systems are highly flexible and permit the formulation of propellants with a wide range of mass impetus characteristics and relatively low flame temperatures, typically below 3000° K. when measured at constant volume.

In accordance with the foregoing, it is an object of this invention to provide improved solid propellants and particularly improved solid propellants for propelling projectiles.

A further object of the invention is to provide gun propellants with relatively low flame temperatures in order to avoid excessive gun barrel erosion.

A still further object of the invention is to provide gun propellant compositions which can be formulated with a wide range of mass impetus and particularly with a mass impetus above that of the standard double-base gun propellant.

An additional object of the invention is to provide gun propellant compositions which evolve non-corrosive combustion products when burned and yet are capable of manufacture by standard equipment into non-, mono- or multi-perforated gun-type grains.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present gun propellants do not contain metal fuels since metal particles in the propellant exhaust lead to undesirable gun barrel erosion. The gun propellants preferably contain only carbon-hydrogen-oxygen-nitrogen in order to obtain an all gaseous, non-corrosive combustion product. The components of the gun propellant compositions are preferably high nitrogen and hydrogen containing materials which have low carbon and oxygen content in order to avoid high average molecular weight exhaust products. A low molecular weight of the combustion products is desirable to increase the value of the specific impulse.

Triaminoguanidine nitrate (TAGN) is a dense, nonhygroscopic, thermally stable solid and is readily prepared in high yields from guanidine nitrate and hydrazine (Diamond, L. H. Derivatives of Hydrazine, Publication No. 10, 466, University Microfilms, Ann Arbor, Mich., 1954). It can also be prepared by the aqueous fusion of calcium

cyanamide and hydrazine nitrate and also by reacting a mixture of hydrazine nitrate and hydrazine hydrate with dicyandiamide (U.S. Pat. 3,285,958). TAGN functions as an oxidizer and coolant in the propellant system and has been found to allow the attainment of higher mass impetus and lower flame temperatures that can be obtained by the use of conventional coolants such as nitroguanidine and oxamide. TAGN is used alone or in conjunction with other oxidizers such as cyclotrimethylene trinitramine or cyclotetramethylene tetranitramine. The binder system is based on nitrocellulose and is preferably a highly nitroplasticized nitrocellulose binder system. Conventional stabilizers are added to the binder system as will be discussed below.

The TAGN will normally comprise from 25 to 80 weight percent of the propellant composition. It is generally preferred that the solid propellant composition contain about 50 to 80 weight percent TAGN with the remainder of the composition comprising plasticized nitrocellulose binder. As previously stated, the TAGN oxidizer can either be used alone or in combination with other oxidizers. It is generally preferred to reduce the amount of TAGN employed by the amount of secondary oxidizer added. Cyclotrimethylene trinitramine (RDX) and cyclotetramethylene tetranitramine (HMX) are the preferred secondary oxidizers since they have relatively high nitrogen and hydrogen contents and relatively low carbon and oxygen contents, relatively high positive heats of formation, high density, satisfactory thermostability and reasonable impact sensitivity, as well as being nonhygroscopic. RDX is the oxidizer of choice, primarily because of cost and availability. The gun propellants oridinarily will contain from about 0 to 30 weight percent RDX or HMX, and preferably from about 0 to 20 weight percent.

The gun propellant binder is plasticized nitrocellulose. The nitrocellulose content of the composition will normally vary in the range of 5 to 30% by weight and will preferably be in the range of 5 to 10% by weight when a hightly nitroplasticized nitrocellulose binder system is employed. The weight percent of nitrogen in the nitrocellulose will normally be in the range of 12.5 to 13.5% as is conventional in smokeless powder formulations.

The plasticizer system is preferably a known energetic system comprising a blend of trimethyolethane trinitrate (TMETN) and triethylene glycol dinitrate (TEGDN). The weight relationship of the ingredients in this energetic plasticizer blend may be varied depending on the performance desired. The plasticizer for the nitrocellulose will usually be present in about 5 to 30 weight percent of the gun propellant composition.

It has been found by J. E. Flanagan and V. E. Haury, a co-inventor herein, that useful TAGN containing gun propellants can also be formulated employing non-energetic plasticizers, particularly if gun propellants with a mass impetus below that of the standard double-base gun propellant are considered suitable for the intended use. This discovery is disclosed and claimed in application Ser. No. 192,717, filed concurrently herewith for "Gun Propellant Containing Nonenergetic Plasticizer, Nitrocellulose and Triaminoguanidine Nitrate." The preferred nonenergetic plasticizers of this concurrently filed application are the polyalkylene glycols such as polyethylene glycol and polypropylene glycol and their alkyl ether derivatives such as butyl Carbitol.

Conventional stabilizers are added to the gun propellant to insure acceptable stability or, in other words, acceptable resistance to chemical deterioration. Illustrative stabilizers include nitrodiphenylamine (NDPA) and ethyl centralite (N,N' - diethylcarbanilide). Ethyl centralite (EC) is used in combination with resorcinol (Res) in the preferred compositions. The quantity of stabilizer added to the propellant is typically ½ to 1½ weight percent.

The propellants of this invention can be manufactured utilizing conventional smokeless powder equipment. The individual grains are of conventional size and may be non-perforated, mono-perforated, or multiperforated, such as grains containing seven perforations. The grains may be cylindrical or rosette in configuration.

Table I lists the composition of four preferred gun propellants falling within the scope of the present invention along with their mass impetus and flame temperature. The table illustrates that the present gun propellant systems are highly flexible and permit the formulation of propellants with a wide range of mass impetus and relatively low flame temperatures. In fact, all of the illustrated gun propellant formulations have theoretical isochoric flame temperatures below 3000° K.

TABLE I

	Weight percent			
un propellant formulation number	1	2	3	4
Oxidizer:				
TAGN	50.0	67.0	72.0	80.0
RDX	17.0		2.0	
Binder: NC (12.6% N)	6.0	6.0	6.0	7.0
Plasticizer:				
TEMETN	23.0	23.0	4.0	4.0
TEGDN	2.5	2.5	15.0	8.0
Stabilizer:				
NPDA			1.0	1.0
EC	1.3	1.3		
RES	0.2	0.2		
$I_m \times 10^{-3}$ (ft.-lbs./lb.) (calcd.)	405.0	387.0	375.6	378.6
T', °K. (calcd.)	2,973	2,729	2,566	2,581

The preferred compositions of the invention are the highly nitroplasticized nitrocellulose binder compositions. The following example demonstrates the preparation of such compositions:

EXAMPLE

Ingredient:	Weight percent
RDX	12.0
TAGN	55.0
TMETN	23.0
TEGDN	2.5
NC (12.6% N)	6.0
EC	1.3
Res	0.2

The ingredients were thoroughly mixed in a 1-pint Baker-Perkins vertical mixer at ambient temperature to form a 1-pound batch of propellant and then pressed into strands. The strands were cured at 55° C. for 48 hours. Impact sensitivity, thermal stability [differential thermal analysis (DTA) and Taliani] and burning rates (r) of the propellant were measured. These physical properties as well as some thermodynamic properties of the propellant are summarized in Table II.

TABLE II

Thermodynamic properties

Mass impetus (calc.)	ft.-lbs./lb	400,000
T_v, ° K. (calc.)		2892

Physical properties

Impact sensitivity (RDX=125)	in.-lbs	65

Thermal stability, Taliani:

Temperature, ° C.:	Ml./gas/g./hr.
75	0.001
90	0.003
100	0.020
110	0.060

DTA: Onset/peak of exotherm	° C	145/183

Burning rate properties

Pressure (p.s.i.g.):	r, in./sec.
400	0.273
600	0.377
800	0.474
1000	0.553
1200	0.648
1500	0.747

Exponent (n)=0.78.

As further illustrative of the present invention, a propellant formulation was prepared containing, by weight, 78% TAGN, 7% nitro-cellulose (12.6% N), 10% TEGDN, 4% TMETN and 1% NDPA. The propellant, 8 grams, in the form of .03 in. thick discs .03 in. diameter, was fired in a 20 mm. Mann barrel. A maximum pressure of 25.2 k.p.s.i. was obtained. In a second test, 10 grams of a 7-perforated grain was fired. The length of the propellant grain was 0.17 in., the diameter was 0.19 in. and the perforations were 0.26 in. A maximum pressure of 44.8 k.p.s.i. was obtained in this firing. These tests demonstrated that, although the weight and size of the propellant charges were not optimized, smooth ignition and combustion were obtained.

It will be obvious to those skilled in the art that other plasticizers as well as other stabilizers and secondary oxidizers can be substituted for the illustrated ingredients. For example, the plasticizer could be diethylene glycol dinitrate or bis(dinitropropyl)acetal-formal and the secondary oxidizer could be methylene or ethylene dinitramine.

The above description is for the purpose of illustration and clarification only and it is intended that the scope of the invention not be limited except by reference to the appended claims.

We claim:

1. A non-metallized, solid gun propellant composition comprising a cured intimate mixture of triaminoguanidine nitrate, a nitroplasticizer and nitrocellulose binder.

2. The solid gun propellant composition of claim 1 in which the composition contains, by weight, 25 to 80% of triaminoguanidine nitrate.

3. The solid gun propellant composition of claim 1 in which the composition contains, by weight, 50 to 80% of triaminoguanidine nitrate.

4. A non-metallized, solid gun propellant composition comprising a cured intimate mixture of, by weight, 25 to 80% of triaminoguanidine nitrate, 0 to 30% of cyclotrimethylene trinitramine or cyclotetramethylene tetranitramine, 5 to 30% of nitrocellulose and 5 to 30% of a nitroplasticizer for said nitrocellulose.

5. The solid gun propellant composition of claim 4 in which the nitroplasticizer is a combination of trimethylol ethane trinitrate and triethylene glycol dinitrate.

6. The solid gun propellant composition of claim 4 in which the composition contains 0 to 20% of cyclotrimethylene trinitramine or cyclotetramethylene tetranitramine.

7. The solid gun propellant composition of claim 4 in which the composition contains 5 to 10% of nitrocellulose.

8. The solid gun propellant composition of claim 4 in which the composition is in the form of a multi-perforated grain.

9. The solid gun propellant composition of claim 8 in which the grain has seven perforations.

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U.S. Cl. X.R.

149—36, 92, 94