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3,013,382

MONOPROPELLANTS

Richard C. Doss, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware
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20 Claims. (Cl. 60—35.4)

This invention relates to monopropellant compositions suitable for use in rocket motors. In a further aspect, this invention relates to a method of operating such motors.

Rocket motors are operated by burning a mixture of fuel and oxidant in a combustion chamber and causing the resulting gases to be expelled through a nozzle at high velocity. Liquid propellants are preferred over solid propellants where it is necessary to vary thrust during flight. Liquid propellants are classified as bipropellants and monopropellants and the latter are either a single compound or mixtures of compounds. Monopropellant systems are advantageous in that they require only one tank, one pump, one nozzle, one fuel line, one set of controls, etc. Furthermore, no mixing or proportioning system is required.

The principal elements of a rocket motor utilizing a liquid fuel comprise a combustion chamber, exhaust nozzle, an injection system, and propellant control valves. The propellant gases are produced in the combustion chamber at pressures governed by the chemical characteristics of the propellant, its rate of consumption, and the cross-sectional area of the nozzle throat. The gases are ejected into the atmosphere through the nozzle with supersonic velocity. The function of the nozzle is to convert the pressure of the propellant gases into kinetic energy. The reaction of the discharge of the propellant gases constitute the thrust developed by the rocket motor.

In copending application Serial No. 678,243, filed August 14, 1957 by H. M. Fox there are disclosed and claimed two-component monopropellant compositions suitable for use in rocket motors and a method of operating such motors using said monopropellants. Broadly speaking, said monopropellant compositions comprise an amine nitrate and a suitable oxidant, for example, nitric acid. I have found that the utility of said monopropellants comprising a mixture of an amine nitrate and nitric acid can be enhanced by incorporating a minor amount of a stabilizing agent in said mixture. The incorporation of said stabilizing agent increases the storage stability of said mixtures, i.e., the monopropellant mixture can be stored at higher temperatures for longer periods of time. Thus, broadly speaking, the present invention comprises the use of a stabilized mixture of an amine nitrate and nitric acid as a monopropellant.

An object of this invention is to provide an improved monopropellant composition. Another object of this invention is to provide a method of operating rocket motors using said improved monopropellant composition. Still another object of this invention is to stabilize a monopropellant composition comprising a mixture of an amine nitrate and nitric acid. Other aspects, objects, and advantages of the invention will be apparent to those skilled in the art in view of this disclosure.

Thus, according to the invention there are provided improved monopropellant compositions comprising a mixture of (1) a nitric acid oxidant (2) an amine nitrate and (3) a stabilizing agent. Suitable stabilizing agents

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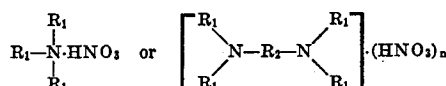
for use in the practice of the invention are carbamide (urea), formamide, acetamide, propionamide, normal butyramide, isobutyramide, hydrogen fluoride, ammonium fluoride, alkali metal fluorides, ammonium acid fluoride, and alkali metal acid fluorides. If desired, mixtures of said stabilizing agents can be employed.

Further according to the invention there is provided a method of operating a rocket motor which comprises the step of injecting the monopropellant compositions of the invention into the combustion chamber of a reaction motor.

It is surprising that the above named compounds can act as stabilizers for the amine nitrate-nitric acid monopropellants because, of a number of compounds tested, such related compounds as thiourea, dithiourea, oxamide, and ethylenediaminedihydrochloride were not found to be effective or reacted violently with the nitric acid.

Very low concentrations (less than 0.1 weight percent of the acid) of the stabilizing agents of the invention can be used in the practice of the invention with beneficial results. However, it is usually desirable to use higher concentrations. Generally speaking, the amount of stabilizing agent used will be within the range of 0.05 to 15 weight percent of the acid in the monopropellant. It is preferable that said stabilizing agents be mixed with the acid prior to mixing said acid with the amine nitrate.

Amine nitrate suitable for use in the practice of the invention include, among others, piperidine nitrate, pyridine nitrate, and amine nitrates having a structural formula

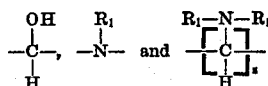


wherein: each R_1 is selected from the group consisting of acyclic, alicyclic, and aromatic hydrocarbon radicals containing from 1 to 8 carbon atoms, and hydrogen; and R_2 is selected from the group consisting of

(a) Alkylene, alkenylene, and alkynylene hydrocarbon radicals containing from 1 to 8 carbon atoms, and



radicals wherein each R_3 is an alkylene radical containing from 1 to 4 carbon atoms, and X is selected from the group consisting of oxygen, sulfur, and



radicals wherein R_1 is defined as above, y is an integer of from 1 to 3, z is an integer of from 1 to 3, and n is an integer from 1 to 5; the total number of carbon atoms in the molecule does not exceed 40, and the total number of amino nitrogen atoms in the molecule does not exceed 10.

Examples of amine nitrates suitable for use in the practice of the invention include, among others, the following: methylamine nitrate; dimethylamine nitrate; trimethylamine nitrate; mono-, di- or triethylamine nitrate;

propylamine nitrate; isopropylamine nitrate; tertiary butylamine nitrate; isobutylamine nitrate; N,N,N',N'-tetramethylbutane - 1,2 - diamine dinitrate; N,N,N',N'-tetraethylpentane - 1,3-diamine dinitrate; N,N,N',N'-tetramethylhexane-3,4-diamine dinitrate; pyridine nitrate; piperidine nitrate, tri-n-octylamine nitrate; N,N-dimethyl-2-butenyl-1-amine nitrate; N-ethyl-2-butyrylamine nitrate; N-isopropyl-3,5-dimethylcyclohexylamine nitrate; 4-cyclohexenylamine nitrate; N,N'-dimethylaniline nitrate; triphenylamine nitrate; N,N-di-n-octyl-p-tolylamine nitrate; α -methylbenzylamine nitrate; diisopropylamine nitrate; N,N,N',N' - tetramethylethane-1,2-diamine dinitrate; N,N,N',N'-tetramethylpropane-1,2 - diamine dinitrate; N,N,N',N'-tetramethylbutane-1,3-diamine dinitrate; ethane-1,2-diaminedinitrate; N,N,N',N'-tetramethyl-2-butyne-1,4 - diamine dinitrate; N,N,N',N'-tetraethyl-ethane-1,2 - diamine dinitrate; N,N,N',N'-tetramethylbutane-1,4-diamine dinitrate; N,N,N',N'-tetramethyl-ocetene-4,8-diamine dinitrate; N-phenyl-N'-n-octylethane-1,2-diamine mononitrate; N,N,N',N'-tetra-n-octyloctane-1,2-diamine dinitrate; N,N,N',N'-tetracyclohexylhexane-2,5-diamine dinitrate; N,N'-di-p-tolylpropane-1,3-diamine mononitrate; N α -dimethylbenzyl-2-butene-1,4-diamine mononitrate; N,N'-dicyclohexenylethane-1,2-diamine dinitrate; N,N,N',N'-tetramethyl-2-butene-1,4-diamine dinitrate; N,N',N',N'-tetraethylpropane-1,3-diamine dinitrate; N-2,4-dimethylcyclohexyl-N'-n-octyl-n-octane-1,8-diamine dinitrate; 1,4-diamino-2-butene dinitrate; N,N,N',N'-tetraphenyl-n-3-octene-1,3-diamine dinitrate, N,N'-di(2-ethylhexyl)-2-butene-1,4-diamine mononitrate; N,N,N'-tri-n-propenyl-2-butene-1,3-diamine dinitrate; N-cyclohexyl-N'-cyclohexenylpropane-1,3-diamine mononitrate; N,N,N',N'-tetraethyl-4-octyne-1,8-diamine dinitrate; N,N'-dimethylethylene-1,2-diamine dinitrate; N,N'-di(2,4-dimethylphenyl)-2-butyne-1,4-diamine mononitrate, N,N-dicyclohexyl-2-pentyne-1,5-diamine dinitrate; N,N,N'-tri-n-butenyl-2-butyne-1,4-diamine mononitrate; bis(N,N-dimethylaminoethyl) ether dinitrate; bis(N,N-di-n-octylamino-n-butyl) ether mononitrate; N-cyclohexylaminopropyl N-phenylaminopropyl ether dinitrate; N-2-ethylphenylaminoethyl amino-n-butyl ether dinitrate; bis(amino-n-butyl) ether dinitrate; bis(N,N-di-2-ethylcyclohexylamino-n-butyl) thioether dinitrate; bis(aminoethyl)thioether mononitrate; bis(N,N-dimethylaminoethyl) thioether dinitrate; N,N,N',N'-tetramethyl-1,3-diamine-2-propanol dinitrate; N,N,N',N'-tetraethyl-1,3-diamino-2-propanol dinitrate; N,N'-diphenyl-1,9-diamino-5-nonanol mononitrate; N,N',N'-tri-2-ethylcyclohexyl-1,4-diamino-2-butanol dinitrate; N,N - di(2,4 - dimethylphenyl) - 1,3 - diamino - 2 - propanol mononitrate; N,N'-dicyclohexenyl-1,4-diamino-2-butanol dinitrate; N,N,N',N'-tetra-n-propenyl-1,6-diamino-4-hexanol mononitrate; N,N'-dimethylethane-1,2-diamine dinitrate; N,N,N',N',N''-pentamethyldiethylenetriamine trinitrate; N,N',N''-tricyclohexyldiethylenetriamine dinitrate; N,N,N',N',N''-pentaphenyldibutylene triamine trinitrate; N,N-di-p-tolyldipropylene triamine mononitrate; N,N,N'-tri-n-octyldiethylenetriamine trinitrate; N,N,N',N',N''-penta - 2 - ethylbutyldiethylene triamine dinitrate; N,N',N''-tri-2-ethylcyclohexenyldiethylenetriamine trinitrate; diethylene triamine trinitrate; N,N,N',N',N'',N''-hexamethylpropane - 1,2,3 - triamine trinitrate, N,N',N'',N''-tetra(2-ethylphenyl) butane-1,2,3,4-tetramine dinitrate; N,N-di(2,4-dimethylcyclohexyl) pentane-1,3,5-triamine trinitrate; N,N,N',N',N'',N''-hexa-2-butenylpropane-1,2,3-triamine mononitrate; propane-1,2,3-triamine trinitrate; N₁N₁N₂N₂N₃N₃N₄N₄N₅N₅ - decamethylpentane-1,2,3,4,5-pentamine pentanitrate, N₁N₂N₃N₄N₅ - pentaethyltetraethylenepentamine trinitrate, N,N,N',N'-tetra-n-propyl-2,4,6-trihydroxyheptane-1,7-diamine dinitrate, N,N,N',N'-tetramethyl-3,6-dioxaoctane-1,8-diamine dinitrate, and 2,4,6-trithiaheptane-1,7-diamine mononi-

trate, and 1,2,3,4,6,7,8,10,11,12-deca(N-methylamino) dodecane pentanitrate.

As used herein the term "alkali metal fluorides" includes sodium fluoride, potassium fluoride, lithium fluoride, rubidium fluoride, and caesium fluoride. The term "alkali metal acid fluorides" includes sodium acid fluoride, potassium acid fluoride, lithium acid fluoride, rubidium acid fluoride and caesium acid fluoride.

Since water tends to retard combustion of the acid with the fuel, the nitric acid is preferably substantially free of water. Thus, the presently most preferred oxidant is anhydrous nitric acid. However, other more dilute nitric acids can be used in the practice of the invention. White fuming nitric acids and red fuming nitric acids of varying concentrations are available commercially, and all are useful in the practice of this invention. White fuming nitric acid usually contains about 90 to 99 weight percent HNO₃, from 0 to 2 weight percent NO₂, and up to about 10 weight percent water. Red fuming nitric acid usually contains about 70 to 90 weight percent HNO₃, from 2 to 25 weight percent NO₂, and up to about 10 weight percent water. Of course, mixtures of the above described acids can be employed to give an acid having any intermediate composition, and all are useful in the practice of this invention. Thus, it has been found that nitric acids of all types containing at least about 70 weight percent HNO₃ are useful as an oxidant in the practice of the invention.

The monopropellants used in the practice of the present invention are preferably near stoichiometric mixtures of the nitric acid and the amine nitrate. The ratio of fuel component to oxidant can be in the range of 0.75 to 1.25 times that of the stoichiometric amount. A slightly fuel-rich mixture is usually required to give optimum rocket motor performance. While, as stated above, the amount of stabilizing agent used in the monopropellants of the invention is within the range of 0.05 to 15 weight percent of the acid, amounts within the range of 0.1 to 5 weight percent are more commonly used.

Amine nitrates can be prepared by several methods. One method is to react an amine with nitric acid. Another method which can be employed is to form a salt of the amine, such as a hydrochloride or an acetate, and then react the amine salt with nitric acid.

EXAMPLE I

A number of runs were made in which polyamine compounds were reacted with nitric acid to form the corresponding amine nitrates. These runs were carried out according to the following procedure.

An amount of the pure polyamine compound was charged to a flask, after which an amount of aqueous nitric acid was charged slowly to said flask by means of a dropping funnel. The temperature of the flask contents was maintained within the range of from 0 to 10° C. by means of an ice bath and by adjusting the rate of addition of the nitric acid to keep the temperature of the reaction mass below 10° C. During the addition of the nitric acid, the flask contents were stirred vigorously. After the nitric acid had been charged, the flask contents were stirred for several minutes to insure complete reaction, after which said flask contents were poured into approximately 5 times its volume of chilled acetone (-10 to -25° C.). The amine nitrate precipitated out. This precipitate was recovered by filtration, washed with cold acetone or ether, and dried in a vacuum desiccator at room temperature. The melting point and stability of the amine nitrate were then determined. None of the amine nitrates which were prepared were found to be shock sensitive to the blow of a hammer. The results of these runs are given below in Table I.

TABLE I

Run No.	Amine Charged	Mols Nitric Acid Charged	Percent Aqueous Acid (Wt. Percent HNO ₃)	Mols Amine Charged	Yield of Amine Nitrate, Percent	M.P. of Amine Nitrate, ° C.
1.	N,N,N',N'-tetramethylethane-1,2-diamine.....	0.606	40.5	0.275	96.3	220-221
2.	N,N,N',N'-tetramethylpropane-1,2-diamine.....	0.606	33.4	0.275	92.3	177-179
3.	N,N,N',N'-tetramethylbutane-1,3-diamine.....	0.606	40.5	0.275	95.0	115-116
3a.	N,N,N',N'-tetramethylbutane-1,3-diamine.....	1.19	70.0	0.578	97.0	115-116
4.	N,N,N',N'-tetramethyl-2-butyne-1,4-diamine.....	0.6	41.0	0.285	96.4	145-146
5.	N,N,N',N'-tetraethylethane-1,2-diamine.....	0.6	41.0	0.285	76.5	142-143
6.	N,N,N',N'-tetramethylbutane-1,4-diamine.....	0.43	70.0	0.208	98.7	173-174
7.	N,N,N',N'-tetramethylbutane-1,2-diamine.....	0.40	70.0	0.183	94.3	173-174
8.	Bis(N,N-dimethylaminoethyl)ether.....	0.51	70.0	1.025	72.0	88-93
9.	N,N,N',N'-tetramethyl-1,3-diamino-2-propanol.....	0.51	70.0	0.25	85.2	120-124
10.	N,N,N',N'-tetraethyl-1,3-diamino-2-propanol.....	0.51	70.0	0.25	91.2	113-114
11.	N,N,N',N',N''-pentamethyldiethylene triamine.....	0.51	70.0	0.23	80.0	162-163
12.	N,N,N',N',N''-hexamethylpropane-1,2,3-triamine.....	0.53	70.0	0.173	65.3	104-106
13.	N,N'-dimethylethylene-1,2-diamine.....	0.505	60.0	0.5	not recorded	125
14.	N,N,N',N'-tetramethyl-2-butene-1,4-diamine.....	0.44	70.0	0.21	88.8	179-180
15.	N,N,N',N'-tetraethylpropane-1,3-diamine.....	0.42	70.0	0.2	97.0	157.5-159.5

¹ In this run, the amine was dissolved in an equal volume of acetone.

EXAMPLE II

White fuming nitric acid (WFNA) of about 92 percent strength and containing a trace of NO₂ was decolorized by passing a stream of dry air through the acid for 3 hours while the temperature was maintained at 140° F. A small amount, about 0.1 weight percent of the acid, of carbamide (urea) was added to the acid to accelerate removal of the oxides of nitrogen which cause coloration of the acid.

Two monopropellants were prepared by mixing a stabilizing agent of the invention with separate portions of the thus freshly prepared acid and then incorporating N,N,N',N'-tetramethylbutane-1,3-diamine dinitrate. The compositions are given in the tabulation below:

Ingredient	Composition, Wt. percent—Propellant No.	
	1	2
Nitric acid (WFNA).....	63	67.7
Dinitrate salt.....	29.7	32.
Carbamide (Urea).....		0.3
Acetamide.....	7.3	

About 10 ml. of each propellant were placed in separate glass tubes and heated slowly to 180° F. The pertinent observations were as follows:

Time, hr.: min.	Temp., F.	Remarks
0:0.....	80	Start of heating.
0:50.....	137	
3:00.....	149	
11:15.....	155	Some bubbles temporarily formed in propellant No. 2.
24.....	160	No discoloration in propellant 1 or 2.
26.....	160	Increasing temperature.
28.....	180	Test terminated. No discoloration at end of test.

When a comparable test is made with unstabilized acid, an intense orange-red color develops in about one hour. By experience this is known to be a danger sign and indicative of pending spontaneous decomposition of the monopropellant.

EXAMPLE III

Preparation of anhydrous nitric acid

To a 5-liter, 3-necked, round bottom flask there were charged 1.5 liters of WFNA (commercial grade—92% nitric acid, 8% water, and containing a trace of NO₂). Fifteen grams of carbamide (urea) were added to the flask and dry air was bubbled through the mixture at 60° C. for 3 hours or until the presence of nitrogen dioxide as indicated by red coloring was removed. The mixture

was cooled to room temperature and 550 milliliters of concentrated sulfuric acid was added. The 3-necked flask was then fitted with a thermometer and a jacketed distillation column which was cooled with ice water. Heat was gradually applied as dry air was bubbled through the mixture. A 51% yield of essentially anhydrous nitric acid which distilled at 45–50° C. was obtained.

EXAMPLE IV

A monopropellant composition containing 33.8 weight percent of N,N,N',N'-tetramethylbutane-1,3-diamine dinitrate and 66.2 weight percent of the anhydrous nitric acid from Example III was prepared by adding said diamine dinitrate to said acid slowly with stirring and while maintaining the temperature between 0–10° C. One portion of said monopropellant composition was used as a control and no stabilizing agent was added thereto. 1.4 weight percent of acetamide (based on the acid) was added to a second portion of said monopropellant. 0.79 weight percent of ammonium fluoride (based on the acid) was added to a third portion of said monopropellant. To a fourth portion of said monopropellant, 1.4 weight percent of acetamide and 0.79 weight percent of ammonium fluoride (based on the acid) was added. The results of storage stability tests at 140° F. on said monopropellant compositions are given in Table II below. Said storage stability values were determined by storing 20 milliliters of the monopropellant compositions in a 30 milliliter stainless steel bomb immersed in a constant temperature bath. Bomb pressure was then recorded versus time in the storage bath until rupture of a 109 p.s.i. safety disc provided in said bomb.

TABLE II

	Stabilizing Agent and Amount Wt. Percent of Acid			
	None	Acetamide 1.4%	Ammonium Fluoride 0.79%	Acetamide 1.4%, Ammonium Fluoride 0.79%
Storage Stability @ 140° F., hrs.	51	57	192	164

EXAMPLE V

A number of monopropellant compositions having the compositions indicated in Table III below were prepared by dissolving the various amine nitrates in anhydrous nitric acid prepared as described above in Example III. Various stabilizing agents in weight percent amounts (based on the acid) were added to the acid prior to dissolving the amine nitrate therein. Storage stability at 140° F. was then determined on said compositions ac-

cording to the method described in Example IV above. The results of said storage stability tests are given in Table III below.

TABLE III

Amine Nitrate and Acid Wt. Percent of Each	Storage Stability at 140° F., Hrs., Stabilizing Agent and Amount (Wt. Percent of the Acid)	
	Acetamide 1.4%	Ammonium Fluoride 0.79%
N,N,N',N'-tetramethylethane-1,2-diamine dinitrate 39.1%; Acid 60.9%	2	
N,N,N',N'-tetramethylpropane-1,3-diamine dinitrate 36.1%; Acid 63.9%	145	38
N,N,N',N'-tetramethylbutane-1,4-diamine dinitrate 33.8%; Acid 66.2%	246	83
N,N,N',N'-tetramethylbutane-1,2-diamine dinitrate 33.8%; Acid 66.2%	317	
N,N,N',N'-tetramethyl-2-butene-1,4-diamine nitrate 34.7%; Acid 65.3%	30	
N,N,N',N'-tetramethyl-2-butyne-1,4-diamine dinitrate 35.7%; Acid 64.3%	6	
N,N,N',N'-tetraethylethane-1,2-diamine dinitrate 30.5%; Acid 69.5%	37	
Bis(dimethylaminoethyl) ether dinitrate 36.2%; Acid 63.8%	100	
N,N,N',N'-tetramethyl-1,3-diamino-2-propanol dinitrate 38.9%; Acid 61.1%	5	
N,N,N',N'-tetraethyl-1,3-diamino-2-propane dinitrate 31.0%; Acid 69.0%	16	
Hexane-1,6-diamine dinitrate 39.1%; Acid 60.9%	2	
N,N'-dimethylethane-1,2-diamine dinitrate 48.6%; Acid 51.4%	240	
Piperidine nitrate 31.1%; Acid 68.9%	299	
Diisopropylamine nitrate 31.1%; Acid 68.9%	Est. 1 year	

It is to be realized that the test at 140° is a severe test and the mere fact that some compounds give mixtures which have a low storage stability at 140° F. does not mean that said compounds are not useful in the practice of the invention because, at lower temperatures, mixtures of said compounds with nitric acid do have higher storage stabilities and can be used at lower temperatures in those instances where storage stability is of secondary importance. The stabilizing agents of the invention are effective for increasing the storage stability at temperatures lower than 140° F. Since the monopropellants of the invention may possibly be used or stored under desert conditions, 140° F. was chosen as a reasonable maximum temperature at which to measure storage stability.

Based on storage stability the presently preferred amine nitrates for use in the practice of the invention are

N,N,N',N'-tetramethylpropane-1,3-diamine dinitrate
N,N,N',N'-tetramethylbutane-1,4-diamine dinitrate
N,N,N',N'-tetramethylbutane-1,3-diamine dinitrate
N,N,N',N'-tetramethylbutane-1,2-diamine dinitrate
Bis-(dimethylaminoethyl) ether dinitrate
N,N'-dimethylethane-1,2-diamine dinitrate
Diisopropyl amine nitrate
Piperidine nitrate.

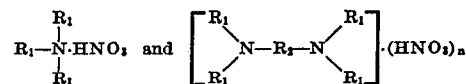
It will be noted that monopropellants of the invention formulated from amine nitrates of this group all have storage stabilities greater than 50 hours. Said monopropellants thus form a definitely superior select group. Other considerations such as availability, etc. will enter into the choice of the most preferred from said select superior group of monopropellants.

Various modifications of the invention can be made, or followed, by those skilled in the art in view of the above disclosure. Such modifications are believed to be within the spirit and scope of the invention.

I claim:

1. A monopropellant composition consisting essentially of a mixture of (1) a nitric acid oxidant containing at least 70 weight percent HNO_3 , (2) an amine nitrate selected from the group consisting of pyridine ni-

trate, piperidine nitrate, and amine nitrates characterized by a formula selected from the group consisting of

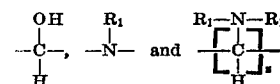


wherein: each R_1 is selected from the group consisting of acyclic, alicyclic, and aromatic hydrocarbon radicals containing from 1 to 8 carbon atoms, and hydrogen; and R_2 is selected from the group consisting of

(a) alkylene, alkenylene, and alkynylene hydrocarbon radicals containing from 1 to 8 carbon atoms, and



radicals wherein each R_3 is an alkylene radical containing from 1 to 4 carbon atoms, and each X is selected from the group consisting of oxygen, sulfur, and



radicals wherein R_1 is defined as above, y is an integer of from 1 to 3, z is an integer of from 1 to 3; and n is an integer of from 1 to 5;

the total number of carbon atoms in the molecule does not exceed 40, and the total number of amino nitrogen atoms in the molecule does not exceed 10; and (3) a stabilizing agent selected from the group consisting of carbamide, formamide, acetamide, propionamide, normal butyramide, isobutyramide, hydrogen fluoride, ammonium fluoride, alkali metal fluorides, ammonium acid fluoride, alkali metal acid fluorides, and mixtures thereof, the ratio of said amine nitrate to said nitric acid oxidant in said mixture being within the range of 0.75 to 1.25 times that of the stoichiometric amount, and said stabilizing agent being present in an amount within the range of 0.05 to 15 weight percent of said nitric acid oxidant.

2. The composition of claim 1 wherein said stabilizing agent is carbamide.

3. The composition of claim 1 wherein said stabilizing agent is acetamide.

4. The composition of claim 1 wherein said stabilizing agent is ammonium fluoride.

5. The composition of claim 1 wherein said stabilizing agent is a mixture of acetamide and ammonium fluoride.

6. The composition of claim 1 wherein said amine nitrate is N,N,N',N'-tetramethylbutane-1,3-diamine dinitrate and said stabilizing agent is ammonium fluoride.

7. The composition of claim 1 wherein said amine nitrate is N,N,N',N'-tetramethylbutane-1,4-diamine dinitrate and said stabilizing agent is acetamide.

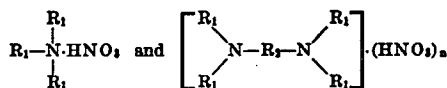
8. The composition of claim 1 wherein said amine nitrate is N,N,N',N'-tetramethylbutane-1,2-diamine dinitrate and said stabilizing agent is acetamide.

9. The composition of claim 1 wherein said amine nitrate is N,N'-dimethylethane-1,2-diamine dinitrate and said stabilizing agent is acetamide.

10. The composition of claim 1 wherein said amine nitrate is diisopropylamine nitrate and said stabilizing agent is acetamide.

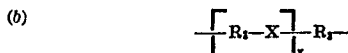
11. In the method for development of thrust by the combustion of a monopropellant in the combustion chamber of a reaction motor, the step comprising injecting into said combustion chamber a mixture consisting essentially of (1) a nitric acid oxidant containing at least 70 weight percent HNO_3 , (2) an amine nitrate selected from the group consisting of pyridine nitrate,

piperidine nitrate, and amine nitrates characterized by a formula selected from the group consisting of

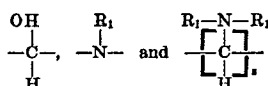


wherein; each R_1 is selected from the group consisting of acyclic, alicyclic, and aromatic hydrocarbon radicals containing from 1 to 8 carbon atoms, and hydrogen; and R_2 is selected from the group consisting of

(a) alkylene, alkenylene, and alkynylene hydrocarbon radicals containing from 1 to 8 carbon atoms, and



radicals wherein each R_3 is an alkylene radical containing from 1 to 4 carbon atoms, and each X is selected from the group consisting of oxygen, sulfur, and



radicals wherein R_1 is defined as above, y is an integer of from 1 to 3, z is an integer of from 1 to 3, and n is an integer of from 1 to 5;

the total number of carbon atoms in the molecule does not exceed 40, and the total number of amino nitrogen atoms in the molecule does not exceed 10; and (3) a stabilizing agent selected from the group consisting of carbamide, formamide, acetamide, propionamide, normal butyramide, isobutyramide, hydrogen fluoride, ammonium fluoride, alkali metal fluorides, ammonium acid fluoride, alkali metal acid fluorides, and mixtures thereof, the ratio of said amine nitrate to said nitric acid oxidant in said mixture being within the range of 0.75 to 1.25 times that of the stoichiometric amount, and said

stabilizing agent being present in an amount within the range of 0.05 to 15 weight percent of said nitric acid oxidant.

12. The method of claim 11 wherein said stabilizing agent is carbamide.

13. The method of claim 11 wherein said stabilizing agent is acetamide.

14. The method of claim 11 wherein said stabilizing agent is ammonium fluoride.

15. The method of claim 11 wherein said stabilizing agent is a mixture of acetamide and ammonium fluoride.

16. The method of claim 11 wherein said amine nitrate is N,N,N',N'-tetramethylbutane-1,3-diamine dinitrate and said stabilizing agent is ammonium fluoride.

17. The method of claim 11 wherein said amine nitrate is N,N,N',N'-tetramethylbutane-1,4-diamine dinitrate and said stabilizing agent is acetamide.

18. The method of claim 11 wherein said amine nitrate is N,N,N',N'-tetramethylbutane-1,2-diamine dinitrate and said stabilizing agent is acetamide.

19. The method of claim 11 wherein said amine nitrate is N,N'-dimethylethane-1,2-diamine dinitrate and said stabilizing agent is acetamide.

20. The method of claim 11 wherein said amine nitrate is diisopropylamine nitrate and said stabilizing agent is acetamide.

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