(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 070 031 B9

(12) **CORRECTED EUROPEAN PATENT SPECIFICATION**
Note: Bibliography reflects the latest situation

(15) Correction information:
Corrected version no 1 (W1 B1)
Corrections, see page(s) 3

(48) Corrigendum issued on:
02.05.2003 Bulletin 2003/18

(45) Date of publication and mention of the grant of the patent:
27.11.2002 Bulletin 2002/48

(21) Application number: **99914804.2**

(22) Date of filing: **14.04.1999**

(51) Int Cl.[7]: **C06D 5/08**

(86) International application number:
PCT/NL99/00216

(87) International publication number:
WO 99/052839 (21.10.1999 Gazette 1999/42)

(54) MONOPROPELLANT SYSTEM

MONERGOLES FLÜSSIGES TREIBSTOFFSYSTEM

SYSTEME DE MONERGOL

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI NL PT SE

(30) Priority: **15.04.1998 EP 98201190**

(43) Date of publication of application:
24.01.2001 Bulletin 2001/04

(73) Proprietor: **NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUURWETENSCHAPPELIJK ONDERZOEK TNO**
2628 VK Delft (NL)

(72) Inventors:
- **VAN DEN BERG, Ronald, Peter**
  NL-2291 KJ Wateringen (NL)
- **ELANDS, Petrus, Johannes, Maria**
  NL-2804 LK Gouda (NL)
- **MUL, Johannes, Maria**
  NL-2012 AE Haarlem (NL)

(74) Representative: **Prins, Adrianus Willem et al**
Vereenigde,
Nieuwe Parklaan 97
2587 BN Den Haag (NL)

(56) References cited:
WO-A-91/19669
WO-A-94/10104
WO-A-97/06099
US-A- 5 316 749
US-A- 5 648 052

- **DATABASE COMPENDEX ENGINEERING INFORMATION, INC., NEW YORK, NY, US OXLEY J C ET AL: "Thermal decomposition studies on ammonium dinitramide (ADN) and N and H isotopomers" XP002075366 & J PHYS CHEM A;JOURNAL OF PHYSICAL CHEMISTRY A JUL 31 1997 ACS, WASHINGTON, DC, USA, vol. 101, no. 31, 31 July 1997, pages 5646-5652,**
- **AGRAWAL J P: "Recent trends in high-energy materials" PROGRESS IN ENERGY AND COMBUSTION SCIENCE, vol. 24, no. 1, 1998, page 1-30 XP004107967**
- **CHEMICAL ABSTRACTS, vol. 123, no. 14, 2 October 1995 Columbus, Ohio, US; abstract no. 174351p, T. ANAN ET AL.: "Physical and chemical properties of HNF" page 281; XP000663569 & KAYAKU GAKKAISHI, vol. 56, no. 3, 1995, pages 99-104,**

EP 1 070 031 B9

Description

[0001] The present invention is in the area of monopropellant composition systems, for instance for spacecraft propulsion, in emergency systems for jet fighters or in emergency gasgeneration systems for submarines.

[0002] Spacecraft propulsion is defined as that needed for the orientation (attitude control) and positioning (orbit control including de-orbiting) of spacecraft after delivery into the required orbit by the launch vehicle. It is quite separate and distinct from launcher propulsion. The need for spacecraft propulsion begins with its separation from the launch vehicle and terminates at the end of its useful service life. It is usually the depletion of the spacecraft's propellant that terminates its mission.

[0003] Typical requirements for attitude and orbit control are very low thrust (0.1 N typically), a pulsed operational mode for attitude control, a continuous operational mode for orbit control and accurate and repeatable performance and reliable leak-free operation. For de-orbiting the thrust can be higher.

[0004] The propulsion in this area is amongst others generated by so-called monopropellant thrusters, wherein a propellant is catalytically or thermally decomposed into hot gases which are then expanded through a nozzle. In the area of monopropellants hydrogen peroxide and hydrazine are presently traditionally used. They provide a specific impulse of respectively 1872 and 2266 m/s at an expansion ratio of 50, zero ambient pressure, chamber pressure of 1 MPa and at chemical equilibrium outflow conditions.

[0005] Both systems have, however, some drawbacks. Hydrogen peroxide is known for its instability and autodecomposition behaviour. Drawbacks of hydrazine are its toxicity and flammability.

[0006] These aspects of currently used monopropellants accordingly require high level, and thus costly, requirements for production, transport, storage, handling and disposal.

[0007] The same problems are encountered in emergency systems for jet fighters (emergency start-up of engine after flame-out) and submarines (emptying ballast tanks in emergency situation by generating gas).

[0008] It is one of the objects of the present invention to provide a monopropellant composition for spacecraft propulsion and the other uses described above, which obviates these drawbacks of the prior art system. It is a further object to provide a stable, clean, less toxic, and/or less flammable monopropellant composition. It is also an object to provide a monopropellant composition for spacecraft propulsion that could contribute to a relaxation of requirements and therefore to a reduction of costs and launch preparation time.

[0009] The present invention is based on the surprising finding that known solid high energy oxidisers such as hydrazinium nitroformate and ammonium dinitramide, when dissolved in water provide a liquid monopropellant system having a specific impulse that could be equal to the specific impulse of the conventional monopropellants, without having the disadvantages thereof.

[0010] The invention is accordingly directed to a solution of hydrazinium nitroformate and/or ammonium dinitramide in water and/or a C_1-C_4 alkanol, as monopropellant composition, especially in spacecraft propulsion. The amount of water and/or C_1-C_4 alkanol, in the system should be such that the system is liquid, which determines the lower level of the amount of water. On the other hand there should be sufficient hydrazinium nitroformate and/or ammonium dinitramide present in the system to provide the required impulse. Due to the nature of spacecraft propulsion, this specific impulse of the propellant system should be as high as possible, in order to prolong the lifetime of the satellite.

[0011] According to a preferred embodiment hydrazinium nitroformate in water is used. In another embodiment of the propellant system according to the invention additionally an amount of an organic solvent, for example a C_1-C_4 alkanol, such as methanol, ethanol, propanol or butanol, can be used. It has been found that this increases the specific impulse of the monopropellant. The amount of alkanol in the solution is preferably between 0 and 70 wt.%, whereas methanol and/or ethanol are preferred.

[0012] An especially preferred system consists of 25 to 75 wt.% of hydrazinium nitroformate, 5 to 50 wt.% of water and 0 (more preferred 5) to 25 wt.% of C_1-C_4 alkanol.

[0013] In accordance with the invention it is also possible to include other additives in the propellant system, including, but not limited to solubilisers, vapour pressure decreasing agents and performance improving agents.

[0014] In another embodiment the present invention is directed to a process for orienting and positioning of spacecraft after delivery into the required orbit by a launch vehicle using a spacecraft propulsion system based on monopropellant thrusters, wherein the monopropellant discussed hereinabove is used for propulsion.

[0015] Hydrazinium nitroformate and ammonium dinitramide are known high energy solid oxidisers. The use of hydrazinium nitroformate as ingredient in high performance propellant combinations for rocket engines is for example disclosed in European patent application 350,136. A production process for hydrazine nitroformate is further disclosed in the international patent application WO-A 9410104. Ammonium dinitramide is also a known material, the production of which is for example disclosed in WO-A 9424073.

[0016] The monopropellants according to the invention can be used in the conventional way for spacecraft propulsion, in existing systems, whereby it is to be noted that due to the

[0017] The monopropellants according to the invention can be used in the conventional way for spacecraft propulsion,

in existing systems, whereby it is to be noted that due to the properties of the system, less strict requirements concerning storage, transport and handling are possible. Also the use of the monopropellant system as emergency propellant in jet fighters and emergency gas generation systems for submarines is within the scope of the present invention.

Description of the figure.

[0018] The figure shows a comparison of specific impulse of various propellant systems.

[0019] The specific impulse of various monopropellant systems in accordance with the invention has been compared with the values for an aqueous solution of ammonium dinitramide and hydrazinium nitroformate in water, at 50 wt.% water. In the following table and in the figure the specific impulse is given for an expansion ratio of 50 and a chamber pressure of 1 MPa, zero ambient pressure and at chemical equilibrium outflow conditions.

Table 1

	Specific Impulse m/s		
Ingredient	Based on 50% water and 50% oxidiser		For the pure oxidiser
Hydrazinium Nitroformate (HNF) Ammonium Dinitramide (ADN) Hydrogen Peroxide (H_2O_2) Hydrazine (N_2O_4)	1754		2950
	1267		2319
		1872	
		2266	

[0020] As can be seen in the table 50% oxidisers/water mixtures result in a performance loss compared to hydrogen peroxide and hydrazine. This performance loss may be acceptable in view of the reduction of cost due to simpler procedures for production, transport, storage, handling and disposal. Furthermore, by increasing the amount of dissolved oxidiser the performance can be further increased. If fuels such as C_1-C_4 alkanols are added, performance equal to or even exceeding the performance of hydrazine is possible.

[0021] In the attached figure the specific impulse is given for various compositions of hydrazinium nitroform in water, using various concentrations, ammonium dinitramide in water using various concentrations and for a combination of hydrazinium nitroform, ethanol and water.

Claims

1. Monopropellant composition for propulsion and/or gas generation, comprising a solution of hydrazinium nitroformate (HNF) and/or ammonium dinitramide (ADN) in water and/or an organic solvent, and wherein the amount of HNF and/or ADN is from 25 to 95 wt.% of the composition.

2. Monopropellant composition according to claim 1, comprising water and an amount of an organic solvent.

3. Monopropellant composition according to claim 2, wherein the solvent is an alkanol, preferably a C_1-C_4 alkanol.

4. Monopropellant composition according to claim 3, wherein the alkanol is methanol and/or ethanol.

5. Monopropellant composition according to claim 3 or 4, wherein the amount of alkanol is at most 70 wt.%.

6. Monopropellant composition according to claims 1-5, consisting of 25 to 75 wt.% of hydrazinium nitroformate, 5 to 50 wt.% of water and 0 to 25 wt.% of C_1-C_4 alkanol.

7. Monopropellant composition according to claims 1-6, further comprising solubilisers, vapour pressure decreasing agents and/or performance improving agents.

8. Use of a composition of hydrazinium nitroformate and/or ammonium dinitramide according to claims 1-7 as propellant in spacecraft propulsion.

9. Use of a composition of hydrazinium nitroformate and/or ammonium dinitramide according to claims 1-7 as emergency propellant in jet fighters.

10. Use of a composition of hydrazine nitroformate and/or ammonium dinitramide according to claims 1-7 in an emergency gas generation system for submarines.

11. Process for orienting and positioning of spacecraft after delivery into the normal orbit by a launch vehicle by the use of spacecraft propulsion system based on monopropellant thrusters, wherein the monopropellant according to claim 1-7 is used for propulsion.

12. Use of a composition comprising a solution of HNF and/or ADN for propulsion and/or gas generation.

Patentansprüche

1. Einzeltreibmittelzusammensetzung zum Vortrieb und/oder zur Gaserzeugung, die eine Lösung von Hydraziniumnitroformiat (HNF) und/oder Ammoniumdinitramid (ADN) in Wasser und/oder organischem Lösungsmittel umfasst, und wobei die Menge an HNF und/oder ADN 25 bis 95 Gew.% der Zusammensetzung beträgt.

2. Einzeltreibmittelzusammensetzung nach Anspruch 1, die Wasser und eine Menge an organischem Lösungsmittel umfasst.

3. Einzeltreibmittelzusammensetzung nach Anspruch 2, bei der das Lösungsmittel Alkanol ist, vorzugsweise C_1- bis C_4-Alkanol.

4. Einzeltreibmittelzusammensetzung nach Anspruch 3, bei der das Alkanol Methanol und/oder Ethanol ist.

5. Einzeltreibmittelzusammensetzung nach Anspruch 3 oder 4, bei der die Menge an Alkanol höchstens 70 Gew.% beträgt.

6. Einzeltreibmittelzusammensetzung nach den Ansprüchen 1 bis 5, die aus 25 bis 75 Gew.% Hydraziniumnitroformiat, 5 bis 50 Gew.% Wasser und 0 bis 25 Gew.% C_1- bis C_4-Alkanol besteht.

7. Einzeltreibmittelzusammensetzung nach den Ansprüchen 1 bis 6, die ferner Solubilisierungsmittel, Dampfdruckverminderungsmittel und/oder Leistungsverbesserungsmittel umfasst.

8. Verwendung einer Zusammensetzung aus Hydraziniumnitroformiat und/oder Ammoniumdinitramid gemäß den Ansprüchen 1 bis 7 als Treibmittel zum Vortrieb eines Raumfahrzeugs.

9. Verwendung einer Zusammensetzung aus Hydraziniumnitroformiat und/oder Ammoniumdinitramid gemäß den Ansprüchen 1 bis 7 als Nottreibmittel in Düsenjägern.

10. Verwendung einer Zusammensetzung aus Hydrazinnitroformiat und/oder Ammoniumdinitramid gemäß den Ansprüchen 1 bis 7 als Notgaserzeugungssystem für Unterseeboote.

11. Verfahren zum Orientieren und Positionieren eines Raumfahrzeugs, nachdem es durch ein Startfahrzeug in die normale Umlaufbahn gebracht worden ist, durch die Verwendung eines Raumfahrzeugvortriebssystems, das auf Einzeltreibmitteltriebwerken basiert, wobei zum Vortrieb das Einzeltreibmittel gemäß Anspruch 1 bis 7 verwendet wird.

12. Verwendung einer Zusammensetzung, die eine Lösung von HNF und/oder ADN umfasst, zum Vortrieb und/oder zur Gaserzeugung.

Revendications

1. Composition de monergol pour la propulsion et/ou la génération de gaz, comprenant une solution de nitroformiate d'hydrazinium (HNF) et/ou de dinitramide d'ammonium (ADN) dans de l'eau et/ou un solvant organique et dans

laquelle la quantité de HNF et/ou ADN est de 25 à 95% en poids de la composition.

2. Composition de monergol selon la revendication 1, comprenant de l'eau et une quantité d'un solvant organique.

3. Composition de monergol selon la revendication 2, dans laquelle le solvant est un alcanol, de préférence un alcanol en C_1 à C_4.

4. Composition de monergol selon la revendication 3, dans laquelle l'alcanol est le méthanol et/ou l'éthanol.

5. Composition de monergol selon la revendication 3 ou la revendication 4, dans laquelle la quantité d'alcanol est au maximum de 70% en poids.

6. Composition de monergol selon les revendications 1 à 5, constituée de 25 à 75% en poids de nitroformiate d'hydrazinium, de 5 à 50% en poids d'eau et de 0 à 25% en poids d'alcanol en C_1 à C_4.

7. Composition de monergol selon les revendications 1 à 6, comprenant en plus des agents solubilisants, des agents diminuant la pression de vapeur et/ou des agents améliorant les performances.

8. Utilisation d'une composition de nitroformiate d'hydrazinium et/ou de dinitramide d'ammonium selon les revendications 1 à 7 comme ergol pour la propulsion d'engins spatiaux.

9. Utilisation d'une composition de nitroformiate d'hydrazinium et/ou de dinitramide d'ammonium selon les revendications 1 à 7 comme ergol de secours dans des avions de chasse à réaction.

10. Utilisation d'une composition de nitroformiate d'hydrazinium et/ou de dinitramide d'ammonium selon les revendications 1 à 7 comme système de génération de gaz de secours pour des sous-marins.

11. Procédé d'orientation et de positionnement d'un engin spatial, après sa mise en orbite normale par un véhicule lanceur, en utilisant un système de propulsion d'engins spatiaux à base de systèmes de poussée monergol, dans lequel le monergol selon les revendications 1 à 7 est utilisé pour la propulsion.

12. Utilisation d'une composition comprenant une solution de HNF et/ou d'ADN pour la propulsion et/ou la génération de gaz.

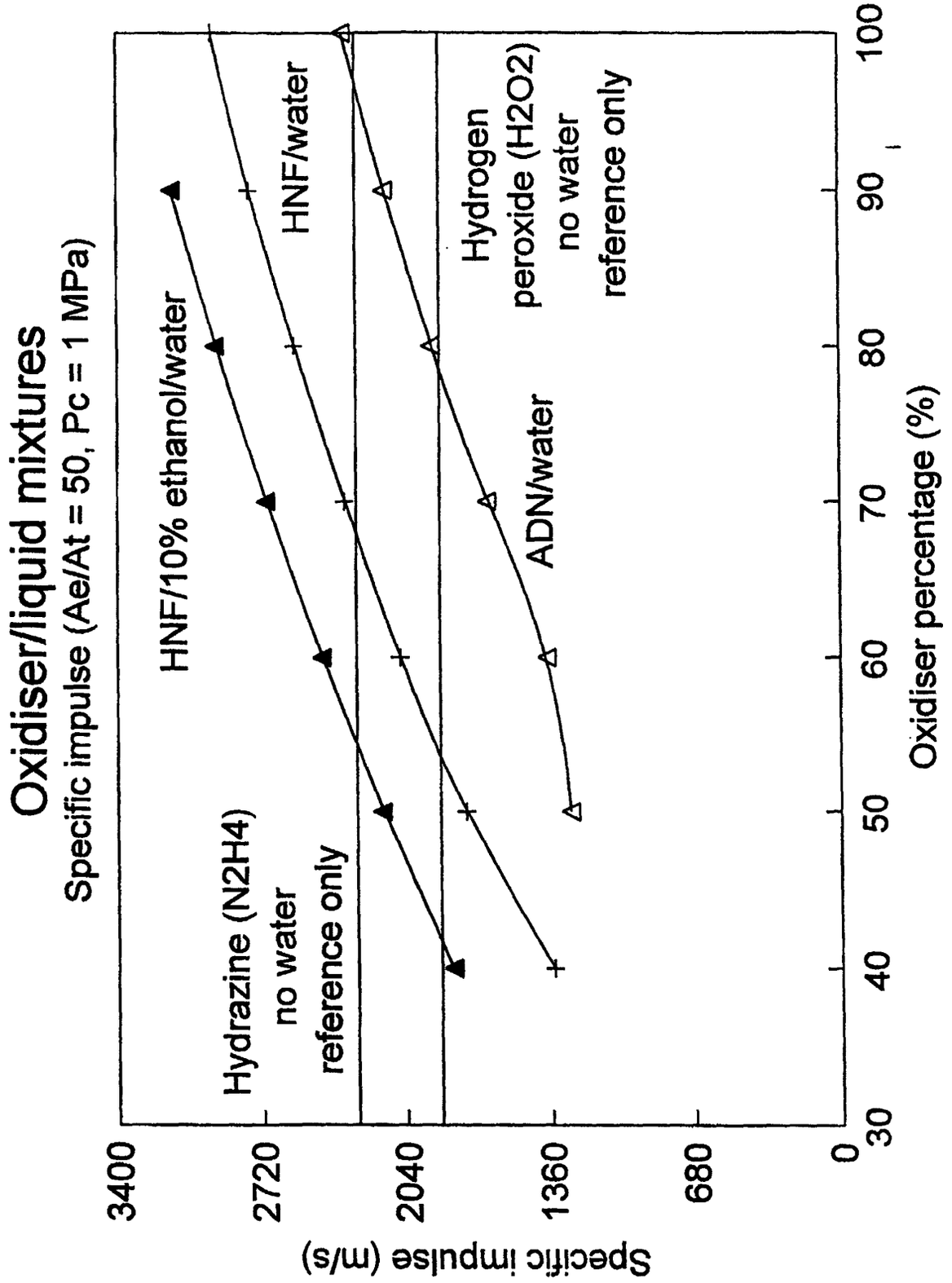
Oxidiser/liquid mixtures
Specific impulse (Ae/At = 50, Pc = 1 MPa)
HNF/10% ethanol/water
HNF/water
Hydrazine (N2H4)
no water
reference only
Hydrogen
peroxide (H2O2)
no water
reference only
ADN/water
Specific impulse (m/s)
3400
2720
2040
1360
680
0
30
40
50
60
70
80
90
100
Oxidiser percentage (%)

Fig. 1