Gas generating solid propellant compositions which utilize sodium azide as a nitrogen source and are further comprised of a fluorocarbon binder material and a combustion catalyst of finely divided colloidal silicon dioxide and/or finely divided carbon black.

12 Claims, No Drawings
SODIUM AZIDE GAS GENERATING SOLID PROPELLANT WITH FLUOROCARBON BINDER

BACKGROUND OF THE INVENTION

This invention relates generally to solid propellants and more particularly to solid propellants especially useful as a self-generating gas pressurization system.

Liquid propellant rocket engines can be classified generally as either pump fed or pressure fed. The pump fed engine extracts the liquid propellants from the tanks and pumps the propellants at high pressure into the combustion chamber. The pressure fed systems admit gas from a high pressure source into the propellant tanks, thus driving the propellants directly into the combustion chamber. The pump fed system requires some pressure in the tanks to push the propellant through the inlet lines and to prevent cavitation in the pump. The requirements for propellant pressurization are generally similar for either type of liquid engine, but the pressures are higher for the pressure fed system.

A self-generating system generates pressurized gas from a solid propellant, as contrasted with a stored gas system, to replace the propellant leaving the main tanks and thereby driving the liquid oxidizer and fuel components into the combustion chamber. Thus a self-generating gas pressurization system which generates inert or neutral gas, such as nitrogen, is compatible with all fuels and oxidizers, is obviously desirable.

Heretofore however, the self-generating gaseous nitrogen pressurization systems have not been completely adequate. Among the primary disadvantages of these prior art systems is that complete combustion is not always accomplished and furthermore deleterious metals are customarily part of the combustion end products which necessitates elaborate filtering means for their removal. Moreover, other problems in the areas of formulation and storage of these heretofore employed systems have also been unfortunately encountered.

SUMMARY OF THE INVENTION

Accordingly, one object of this invention is to provide a gas generating solid propellant.

Another object of this invention is to provide a gas generating solid propellant especially useful as a self-generating gas pressurization system.

Still another object of this invention is to provide a gas generating solid propellant especially useful as a self-generating gas pressurization system of which combustion gas is essentially nitrogen.

A further object of this invention is to provide a gas generating solid propellant particularly useful as a self-generating gas pressurization system which does not produce deleterious combustion end product materials.

A still further object of this invention is to provide a gas generating solid propellant especially useful as a self-generating gas pressurization system which has improved formulation and storage characteristics.

These and other objects are accomplished by providing a solid propellant composition comprised of sodium azide, a polymeric fluorocarbon binder and finely divided colloidal silicon dioxide, finely divided carbon black and mixtures thereof as a combustion catalyst.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The gas generating solid propellant compositions of this invention are based upon the reaction of sodium azide and a fluorocarbon polymer matrix in the presence of finely divided silicon dioxide as illustrated, e.g., by the following general reactions:

(I) \[ 4\text{NaN}_3 + (\text{CF}_2)_n \rightarrow 2\text{SF}_6 + 6\text{Na} + 2\text{C} \]

(II) \[ 8\text{NaN}_3 + (\text{CaF}_2\text{H}_2)_n \rightarrow \text{SF}_6 + 8\text{NaF} + 12\text{N}_2 + \text{H}_2 \]

(III) \[ 3\text{NaN}_3 + (\text{CF}_2)_n \rightarrow 3 + \text{Mg} \rightarrow 5\text{MgF}_2 + 2\text{C} + 3\text{N}_2 \]

(IV) \[ 6\text{NaN}_3 + (\text{CF}_2\text{H}_2)_n \rightarrow 3 + \text{Mg} \rightarrow 5\text{MgF}_2 + 2\text{C} + 9\text{N}_2 + 5\text{C} \]

Thus, the solid propellants of the present invention, as exemplified by general reactions I-IV employ NaN₃ as the source of nitrogen gas. Although other inorganic azides, such as LiN₃, which also is characterized by a relatively high nitrogen content, will perform similarly to the NaN₃ in the propellants of this invention, it is rendered somewhat unsuitable because of its high degree of instability and lack of commercial availability.

With regard to the fluorocarbon binder materials considered to be within the scope of this invention, general reactions I-IV above indicate that such polymeric fluorocarbons as Teflon (polytetrafluoroethylene) and Viton A (a rubbery copolymers of vinylidene fluoride and hexafluoropropylene) may be employed in the practice of this invention. For the purposes of this invention a fluorocarbon is defined as being either a fully fluorinated fluorocarbon consisting of carbon and fluorine or a partially fluorinated fluorocarbon containing some other element or elements besides carbon and fluorine, such as hydrogen, oxygen, nitrogen, halogen, etc. Obviously, in cases where hydrogen gas cannot be tolerated as one of the combustion gases (such as in the case where either the oxidizer or fuel or both of a liquid propellant may not be compatible with hydrogen as part of the pressurized gas) fully fluorinated polymeric fluorocarbons such as e.g. Teflon are preferred since nitrogen is the sole gaseous product. Otherwise partially fluorinated fluorocarbons, such as e.g., Viton A, are acceptable. Although it has been suggested that the solid propellants of this invention are especially useful as self-generating gas pressurization units it will be obvious to one skilled in the art that they are also useful for driving turbines, actuating valves and for all the other purposes for which conventional gas-generating propellants are employed. For these purposes the nature of the gaseous end products, i.e. whether a mixture of hydrogen and nitrogen or essentially all nitrogen, does not play a significant role. Among other polymeric fluorocarbons that may be employed in the practice of this invention are for example, partially fluorinated fluorocarbons containing functional groups. One such material is L-2344 which is a hydroxysterminated fluorocarbon made by Minnesota Mining and Manufacturing Company and has an empirical formula of C₈F₁₄N₃O₂. In this case a curing agent, such as an isocyanate, is incorporated in the binder for
improved physical and mechanical properties. Other polymeric fluorocarbons that are operable as binders herein are for example the polynitrofluorocarlytes, Kel-F wax, which is a homopolymer of chlorotrifluoroethylene, Kel-F elastomer which is a copolymer of chlorotrifluoroethylene and vinylidene fluoride and Teflon - 100 which is a copolymer of tetrafluoroethylene and perfluoropropylene.

It has been surprisingly found that unless the propellant compositions of the present invention incorporate a combustion catalyst selected from the group consisting of a finely divided colloidal silicon dioxide possessing a large surface area and finely divided carbon black possessing a large surface area and mixtures thereof, complete combustion of the reactants is not attainable even at stoichiometric quantities. Therefore, in the presence of these aforeidentified catalysts the propellants of this invention fully combus without yielding any deleterious sodium metal. Specifically, a silicon dioxide within the scope of this invention is Cab-O-Sil, a finely divided colloidal silicon dioxide with a minimum surface area of 175 square meters per gram made by Cabot Inc., Boston, Mass. and a specific carbon black operable herein is known as Graphite -5530 which is described as a finely divided carbon black made by the Asbury Graphite Mill, New Jersey.

Other materials may be added to the gas generating propellant compositions of this invention to attain various other desirable ballistic modifying results. For example, if metals such as magnesium or aluminum are added, (see general reactions III and IV) changes in the burning rates are attained, while coolants, such as ammonium oxalate, oxamide and guanidine nitrate, lower the flame temperatures of the propellants.

For operable results, the amounts materials incorporated in the present gas generators are the following: sodium azide, from about 50 to about 75 percent by weight, fluorocarbon binder, from about 25 to about 40 percent by weight and catalyst up to about 10 percent by weight. Any ballistic modifiers, such as hereinabove identified, which may be employed should not comprise more than about 10 percent by weight (for each modifier) of the total composition. For optimum results the reactive ingredients of the propellants of this invention should be present in about stoichiometric quantities.

The general nature of the invention having been set forth, the following examples are presented as specific illustrations thereof and also so that invention be better understood. Furthermore, it will be understood that the invention is not limited to these examples but is susceptible to various modifications that will be recognized by one of ordinary skill in the art.

### EXAMPLE I

| sodium azide | Percent by weight | 69.7 |
| Teflon (powder) | 26.8 |
| Graphite -5530 | 3.5 |

(a finely divided carbon black made by Ashbury Graphite Mill, New Jersey)
The propellant compositions of this invention are easily formulated employing conventional techniques. For example, when Teflon powder is utilized as the binder all the propellant ingredients are simply mixed homogenously in a V blender and then either extruded or compression molded. When the binder employed is of the Viton A type, i.e., a rubbery texture, a slurry mixing process is used. This process involves mixing the binder in a solvent such as acetone, followed by the addition of the remaining ingredients and then stripping off the acetone. The formulation is then either extruded or compression molded. When a thick liquid binder such as L-2343 is used a slurry mix process may be employed or a standard solventless mixing procedure is applicable. Again the mixture may be either extruded or compression molded.

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 as new and desired to be secured by Letters Patent of the United States is:

1. A gas generating solid propellant composition comprising sodium azide, a fluorocarbon binder material, and a combustion catalyst selected from the group consisting of a finely divided colloidal silicon dioxide, a finely divided carbon black, and mixtures thereof.

2. The gas generating solid propellant composition of claim 1 wherein said finely divided colloidal silicon dioxide is further characterized by having a minimum surface area of about 175 square meters per gram.

3. The gas generating solid propellant composition of claim 1 wherein said fluorocarbon binder material is a polymeric fully fluorinated fluorocarbon.

4. The gas generating solid propellant composition of claim 1 wherein said fluorocarbon binder material is a polymeric partially fluorinated fluorocarbon.

5. The gas generating solid propellant composition of claim 1 which further includes a metal selected from the group consisting of magnesium and aluminum.

6. The gas generating solid propellant composition of claim 1 wherein said sodium azide is present in an amount within the range of from about 50 to about 75 weight percent, said fluorocarbon binder material is present in an amount within the range of from about 25 to about 40 percent by weight and said combustion catalyst is present in an amount up to about 10 percent by weight.

7. The gas generating solid propellant composition of claim 1 wherein said sodium azide and said fluorocarbon binder material are present in about stoichiometric quantities.

8. The gas generating solid propellant composition of claim 1 wherein said fluorocarbon material is selected from the group consisting of polytetrafluoroethylene, and a copolymer of vinylidene fluoride and perfluoropropylene.

9. The gas generating solid propellant composition of claim 3 wherein said polymeric fully fluorinated fluorocarbon is polytetrafluoroethylene.

10. The gas generating solid propellant composition of claim 4 wherein said polymeric partially fluorinated fluorocarbon is a copolymer of vinylidene fluoride and hexafluoropropylene.

11. The gas generating solid propellant composition of claim 4 wherein said polymeric partially fluorinated fluorocarbon is a homopolymer of chlorotrifluoroethylene.

12. The gas generating solid propellant composition of claim 4 wherein said polymeric partially fluorinated fluorocarbon is a copolymer of vinylidene fluoride and chlorotrifluoroethylene.