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SOLID COMPOSITE PROPELLANTS CONTAINING POLYALKYLENE OXIDES

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The present invention relates to compositions of solid charges for exothermic gas generation by even non-detonating combustion. This invention more particularly relates to fuels adapted for use as propellants of rocket propulsion motors and provides a smokeless propellant of a so-called solid type capable of a high burning rate and particularly adapted for such use.

It is common practice to use in the combustion chambers of rocket propulsion motors solid or plastic propellant mixtures which are burned to produce combustion products which in turn are exhausted through a nozzle at high velocity to produce a thrust. These propellant charges are composed of an inorganic oxidizer such as ammonium perchlorate or ammonium nitrate, a fuel, and a binder. The present compositions and procedures, however, are not completely satisfactory and present problems which have not yet been resolved. Many of the binders require lengthy and complex processing to produce the required characteristics. The addition of extraneous and undesirable impurities such as those commonly required in curing of rubber and similar compounds and curing periods of up to 72 hours are often required. It is likewise common practice to incorporate materials, generally classed as plasticizers, into the fuel binder for the purpose of preventing freezing and brittleness of the solid propellant mass at low temperature operation in the neighborhood of -20° F. to -70° F. Freezing and brittleness result in fissure formation in the charge which increases the burning surface, consequently increasing the rate of gas evolution. The constricted exhaust nozzle thereby becomes inadequate, resulting in high internal chamber pressures and explosion. The combustion of propellant containing additives has the additional disadvantage of leaving undesirable residues and in many instances producing toxic gases.

It is, therefore, the object of the present invention to provide an improved rocket type solid propellant composition. It is a further object of the present invention to provide a fuel and binder for solid rocket propellant which is entirely sufficient for manufacturing a finished charge without the necessity of incorporation of any additive. A still further object of the present invention is to provide a combined fuel and binder for a solid propellant which is smokeless and burns with an invisible flame. These and other objects will become apparent to those skilled in the art as the present description proceeds and from the claims.

It has been discovered that the use of lower polyalkylene oxide, without additives, in combination with an oxidizing material, produces a solid propellant of superior properties. Combustion of the solid propellant of the present invention proceeds at an even, rapid rate of about 2 inches per second at 2000 lbs. per sq. in. chamber pressure without detonation, smoke, or residue. The use of lower polyalkylene oxide, as a fuel binder, as distinguished from the presently known binders, has the advantage of greater oxygen content which causes it to be superior in the combustion reaction. In use, this material is easily blended with known and commonly used oxidizers and may be readily shaped into charges of any desired geometric shape. The charges so made have exceptional physical strength which maintains the proper geometric shape

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with good dimensional stability over a wide range of temperatures from about -76° F. to 145° F. These superior properties are obtained without additives. Cure techniques, involving curing additives and prolonged periods of heating, are not required with a fuel binder of the present invention because it is a thermoplastic at temperatures above 160° F. and is a tough, rubberlike elastomer in temperature ranges of -76° F. to 145° F. Being a thermoplastic elastomer, this material may be formed into the desired geometric shapes by one of many known methods, such as extrusion, injection molding, or compression molding.

The expression "lower polyalkylene oxides" as used herein refers to the normally solid homopolymers of alkylene oxides having from 2 to 4 carbon atoms. These polymers are preferably solids with a softening point in excess of 120° F.

Numerous methods of preparation of the solid polyalkylene oxides are disclosed in the published literature. The method of preparation of the polymer, however, does not alter its effectiveness as a fuel binder. The preferred method of polymerization of the polyalkylene oxide is described in U.S. Patent 2,706,189 and uses a ferric chloride complex polymerization catalyst. The term "crude," as used herein, refers to the polyalkylene oxides prepared by the method therein described and which has not been washed to remove the ferric chloride catalyst. As shown subsequently by the examples, the presence of this ferric chloride in the polymer is in no way detrimental to its use as a fuel binder.

The term "oxidizing agent" as used herein refers to any member of the class of compounds known to the art as agents which donate oxygen for the combustion reaction which occurs in rocket motors. Examples of oxidizers which may be used in the combustion reaction of solid rocket propellants include: ammonium nitrate, potassium nitrate, sodium nitrate, potassium dichromate, guanidine nitrate.

The ratio of oxidizing agent to polyalkylene oxide binder may be varied over a comparatively wide range, depending upon the desired combustion characteristics of the solid propellant charge. It is preferred, however, that the propellant composition contain from 60 to 5% by weight of the polyalkylene oxide.

The oxidizing agent and the fuel binder may be mixed by any appropriate means such as roll mill or Banbury mixer so long as an intimate mixing occurs, giving a substantially homogeneous product.

When it is desired to produce a fuel binder having a higher softening point and concomitant therewith even tougher physical characteristics than the polyalkylene oxide homopolymer, a modification may be effected during manufacture by reaction with from 2-12% by weight of tolyl diisocyanate. The tolyl diisocyanate may be reacted with the alkylene oxide monomer and the product then polymerized or it may be reacted with the polyalkylene oxide prior to admixture with the oxidizing agent. A modified polymer of substantially the same characteristics is obtained from these procedures.

The following examples illustrate the present invention, but are not to be construed as limiting.

Example 1

Ammonium nitrate (83% by weight) was milled into crude polyoxypropylene in a roll mill at 140° F. until a homogeneous mixture was obtained. The polymer was prepared in the manner of U.S. Patent 2,706,189 and had a softening point of 140° F. as determined by ASTM procedure E28-51T. This resulting homogeneous plastic mixture was fed to a preheating chamber of a compression molding machine and thereafter extruded into one-half inch diameter strands and cut into uniform 2-inch lengths.

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The above prepared fuel was charged to a rocket motor and ignited. Upon completion of the burning, which was smokeless, rapid, and without visible flame over the entire period of burning, there was found on examination of the interior of the rocket no residual matter in the combustion chamber.

Example 2

In a substantially analogous manner to Example 1, employing purified polyoxypropylene having a softening point of 145° F. in place of the crude polyoxypropylene, there was attained a fuel product which burned with a smokeless, invisible flame. Combustion proceeded at an even rate throughout the length of the charge. Upon completion of the burning there was no residue in the combustion chamber.

Example 3

Ammonium perchlorate (78% by weight) was milled into crude polyoxypropylene as previously characterized, and extruded in the manner of Example 1 to produce a solid propellant which burned at a rapid, even rate with a smokeless, nearly invisible flame. No residue was observed in the combustion chamber upon completion of the test.

Example 4

A blend consisting of 8 parts of crude polyoxypropylene and 2 parts GR-S rubber was prepared by heating and admixing the components on a roll mill. Thereafter 20 parts by weight of carbon black was thoroughly admixed therein. The resulting mixture was milled in the manner of Example 1 with 85 percent by weight of ammonium nitrate and the resultant admixture extruded into a molded solid propellant.

Upon burning in the rocket motor, there was observed a rapid but even rate, with invisible flame emitting a small amount of smoke. A slight charred residue remained in the combustion chamber.

Example 5

Ammonium perchlorate (73% by weight) was milled into crude polyoxyethylene at 145° F. and compression molded into a cylindrical propellant charge having a diameter of two inches and a length of 1.9 inches. The above prepared solid propellant charge was put into the combustion chamber of a rocket motor and ignited with an electrical heating device of coiled 28 gauge Nichrome wire. Upon completion of the burning, which was smokeless, rapid and without visible flame over the entire period of the burning, there was found on examination of the interior of the rocket no residual matter in the combustion chamber.

Example 6

A tough elastomeric polymer was prepared by the admixing of crude polyoxypropylene with 5 percent by weight of tolyl diisocyanate, having a softening point of 76° C. by ASTM Method E28-51T. This addition resulted in crosslinking. The resultant rubbery polymer was milled in the manner of Example 1 with 80 percent by weight ammonium perchlorate at a temperature of about 194° F. The resulting mixture was molded and burned in a rocket motor in the manner of Example 1.

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The fuel produced a nearly invisible flame with a negligible amount of smoke. The rate of burning was even and rapid. No residue was observed in the combustion chamber.

We claim:

1. A solid propellant composition consisting essentially of an intimate admixture of a solid, inorganic oxidizing salt with a polymer of a lower alkylene oxide, wherein the said polymer is present in the amount from 60 to 50 15% by weight of the solid propellant.

2. A solid propellant composition consisting essentially of an intimate admixture of a solid, inorganic oxidizing salt with a polymer of a lower alkylene oxide having a softening point in excess of 120° F. and wherein the said 15 polymer of a lower alkylene oxide is present in an amount from 60 to 5% by weight of the solid propellant.

3. A composition according to claim 2 wherein the polymer is polyoxyethylene.

4. A composition according to claim 2 wherein the 20 polymer is polyoxypropylene.

5. A solid propellant composition consisting essentially of an intimate admixture of a solid, inorganic oxidizing salt with a polymer of a lower alkylene oxide modified with from 2 to 12 percent by weight of tolyl diisocyanate, 25 wherein said modified polymer is present in an amount of from 60 to 5 percent by weight of the solid propellant.

6. A method for the preparation of a gas generating propellant which comprises the steps of admixing an oxidizing agent selected from the group consisting of 30 solid inorganic oxidizing salts and guanidine nitrate and a polymer of a lower alkylene oxide in proportions such that the lower alkylene oxide polymer is present in an amount of from 60 to 5 percent by weight of the propellant charge, and shaping the so mixed material into a 35 geometric configuration adaptable as a propellant charge.

7. A method according to claim 6 wherein the polymer is polyoxyethylene.

8. A method according to claim 6 wherein the polymer 40 is polyoxypropylene.

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