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3,107,185 HOMOGENEOUS PROPELLANT COMPOSITIONS OF LITHIUM PERCHLORATE AND POLYLACTAM

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No Drawing. Filed Mar. 6, 1958, Ser. No. 719,593
27 Claims. (Cl. 149-2)

This invention relates to novel compositions of matter which are useful as solid rocket propellants and to the process of preparing same. More specifically this invention relates to compositions of matter comprising a lactam polymer and lithium perchlorate and to the process of preparing same, including blending of a polylactam with lithium perchlorate and cast-polymerization of a lactam in the presence of the lithium perchlorate.

Liquid compositions as the fuel-oxidant mixture for rockets present serious problems. The use of liquid propellants require considerable plumbing, valves, metering pumps and intricate controls to provide the means for effecting delivery of the fuel and oxidant to the combustion chamber in the proper ratio. The liquids employed are extremely corrosive and are also subject to loss. Therefore, rockets employing liquid propellant compositions are not reliable for long standing in ready-to-go-condition. Furthermore, handling the corrosive liquids is a hazardous, time-consuming and cumbersome job, which precludes their use in tactical weapon systems in the field and aboard ships.

In contradistinction thereto the solid propellant motor is inherently very simple since the ratio and distribution of fuel, oxidant and additives are fixed when the solid propellant is prepared. Thus the solid propellant system requires no plumbing, valves, or controls and contains no mechanical moving parts which can go wrong. The solid propellant rocket also generally is characterized by relatively long storage life, ease in handling and high reliability, such that it is in constant readiness for instant use, whereby it is well adapted for tactical and strategic weapon systems in field use and aboard ships. A further advantage of the solid propellant rocket is that the relatively rigid propellant charge aids in the support of the chamber during handling and when in use such that a lighter-weight case can be employed, which saving in weight plus the elimination of much hardware required for a liquid propellant system provides a bigger pay-load.

Conventional composite solid propellant compositions generally consist of an inorganic oxidant and a plastic binder, which also serves as the reductant-fuel of the system. The aforesaid system is a heterogeneous composition wherein the burning rate and stability to detonation are dependent to some extent upon the particle size of the oxidant. Both of these properties are improved as the particle size of the oxidant is reduced, but milling to provide a finely divided oxidant is hazardous and periodic explosions are encountered.

The principal object of this invention is to provide an improved solid propellant composition. Another object of this invention is to provide an improved process for casting solid propellant compositions in rocket cases. Still another object of this invention is to provide a novel solid propellant composition having a high specific impulse. A further object of this invention is to provide a novel solid propellant composition which is homogeneous. A still further object of this invention is to provide a novel solid propellant composition characterized by improved stability to shock. Other objects and advantages of this invention will be apparent to those skilled in the art from the following disclosure.

It has now been found that lithium perchlorate and

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the polylactams, wherein the lactam monomer for the said polylactam contains from 5 to 7 members, i.e. from 4 to 6 carbon atoms, in the lactam ring, are mutually soluble and the combination thereof is a homogeneous composition. The presence of the lithium perchlorate renders the polylactam non-crystalline such that the polylactam is in a rubbery, amorphous state, which is tougher than the crystalline polylactam. The aforesaid mutual solubility also is present between the lithium perchlorate and the lactam monomers, e.g., pyrrolidone, piperidone, and ϵ -caprolactam, such that said monomers can be polymerized in the presence of the lithium perchlorate to provide solid homogeneous compositions thereof.

The system lithium perchlorate-polycaprolactam can be employed to further illustrate this invention. Thus, lithium perchlorate is soluble in polycaprolactam and in the monomer ϵ -caprolactam, whereby a homogeneous composite composition is obtained. The lithium perchlorate-polycaprolactam composition can be prepared by blending the two components together at temperatures preferably from about 150° C. to about 250° C. in suitable mixers, extruders, or on a mill roll and the like. The blending operation preferably should be carried out with as little agitation as possible to preclude entrapment of gas in the composition, which would generally require a degassing operation under vacuum. Another method of preparing the lithium perchlorate-polycaprolactam composition is to dissolve the lithium perchlorate in ϵ -caprolactam and add a base catalyst or a catalyst-promoter system, as hereinafter more fully described, whereby the fluid composition can be introduced into any desired container and polymerized in place. The lithium perchlorate-polycaprolactam composition can also be readily extruded for use in relatively small-bore projectiles.

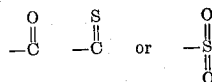
The preferred relatively low temperature, base-catalyzed, N,N-diacyl-initiated polymerization process is disclosed in the copending U.S. application Serial No. 627,984, filed December 13, 1956, now U.S. Patent No. 3,017,391, issued January 16, 1962, of which this application is a continuation-in-part.

Effective base catalysts are the alkali and alkaline earth metal catalysts, which are effective either in the metallic form or in the form of hydrides, borohydrides, oxides, hydroxides, carbonate, amides, etc. Lithium and sodium hydrides are particularly preferred catalysts in the composition of the present invention. The base catalyst is employed in an amount of from about 0.05 percent up to about 5 percent, and preferably from about 0.1 percent up to about 1 percent by weight of the lactam present in the composition.

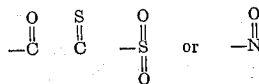
The N,N-diacyl compounds suitable as promoters can be selected from the class of compounds containing the essential active group:



wherein N is a tertiary nitrogen atom (i.e., has no hydrogen atoms attached thereto), A is an acyl radical selected from



and B is an acyl radical selected from

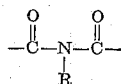


and R is a third substituent of the same kind of general type as A or B; or a hydrocarbyl radical such as aryl,

alkyl, aralkyl, alkaryl, cycloalkyl, etc.; or a heterocyclic radical such as pyridyl, quinolyl, etc.; or any of the aforementioned groups substituted with or containing additional radicals or groups such as carbonyl, N-substituted carbamyl, alkoxy, ether, sulfonyl, tertiary amino, etc.; or any other non-interfering groups, i.e., groups which will not preferentially react with the lactam or which will not otherwise interfere with the essential effective activity of the polymerization catalyst.

The substituents attached to the carbonyl, thiocarbonyl and sulfonyl radicals A and B are unlimited, provided they are free from interfering groups (e.g., primary amino groups or strong acid functions which will interfere with the alkali or alkaline metal catalysts). Examples of non-interfering groups are hydrogen atoms, as well as hydrocarbyl and heterocyclic radicals mentioned in the preceding paragraph, including such radicals substituted with or containing polar-substituents such as tertiary amino, acylamido, N-substituted carbamido, ether, etc. The radicals A and B can be attached together to form a ring system (e.g., the cyclic imides described in greater detail below). Likewise, the radical A and the tertiary nitrogen atom can constitute a part of a ring system not including the radical B (e.g., the lactams described below).

A preferred class of materials having the aforementioned structure are N-substituted imides, i.e., compounds of the foregoing type having at least two acyl groups attached directly to the tertiary nitrogen atom. This group of compounds can be represented by the following structural formula:



A particularly effective class of N-substituted imides are the N-acyl lactams such as N-acetyl-2-pyrrolidone, N-acetyl-ε-caprolactam, N-benzoyl-ε-caprolactam, N-benzoyl-δ-valerolactam, N-ethylcarbamyl-ε-caprolactam, N-propionyl-ω-caprylactam, N-toloyl-ω-decanolactam, etc.

Another preferred class of N-substituted imides comprise the cyclic imides of dicarboxylic acids. Examples of this class are N-phenylsuccinimide, N-phenylmaleimide, N-methylsuccinimide, N-methylphthalimide, N-acetyl-tetrahydrophthalimide, N-benzoylsuccinimide, N-benzoyl-phthalimide, etc.

Another preferred class of N-substituted imides comprise those having a multiplicity of the essential N,N-diacyl tertiary nitrogen atom groups. This class includes compounds in which a portion of the group (for example, an acyl radical) is common to two or more of the essential polymerization promoting structures. Example of this class are the N,N',N''-trimethylester of isocyanuric acid, N,N'-di(phenylcarbamyl)-N,N'-dimethylureas, ethylene disuccinimide, etc.

Examples of other N-substituted imides suitable for the above-described improved polymerization are N,N-diacetylmethylamine, N,N-dibenzoylaniline, triacetamide, N-acetyl-N-formyl ethylamine, N-propionylsaccharin, etc.

Another general class of compounds useful for the polymerization process comprise the N-acyl sulfonamides containing no hydrogen atom on the sulfonamide nitrogen atom. Examples of this general class of materials are N-acetyl-N-ethyl-p-toluene-sulfonamide, N-ethyl-N-laurylethanesulfonamide, N,N-diacetylmethanesulfonamide, N-(phenylsulfonyl)succinimide, N-methylsaccharin, N-acetylsaccharin, N-acetyl-N-methylbenzenesulfonamide and numerous other N-acyl sulfonamides.

Another class of suitable compounds for the polymerization process comprise the disulfonamides such as N,N-di-(p-toluenesulfonyl)anilide, N,N-di-(benzenesulfonyl)methylamine, and other N,N-dibenzenesulfonyl alkylamines, as well as the corresponding N,N-dialkanesulfonylalkylamines such as N,N-di-(methanesulfonyl)-ethylamine, etc.

Another general type of effective promoter compounds

comprise the N-nitrosoamides. Representative members of this class of compounds are N-nitroso-2-pyrrolidone, N-nitrosuccinimide, N,N-diacetylnitrosamine, N-nitroso-N-acetyl-propylamine, N-nitroso - N,N'-di-n-butylurea, N-methyl-N-nitrosourethane and other N-substituted N-nitroso-carbamates, etc.

Another general class of promoters for the polymerization process comprises the N-nitrososulfonamides, such as N-nitroso-N-methyl-benzenesulfonamide, N-nitroso-N-methyl-p-toluenesulfonamide, N-nitroso-N-ethyl-methanesulfonamide, N-nitroso-N-phenethyl-butanesulfonamide, etc.

As was indicated above, one or more of the acyl oxygen atoms of the various compounds described herein can be substituted with sulfur atoms to form the corresponding thioacyl compounds without destroying the effectiveness of such compounds as promoters for the polymerization of the lactams. Examples of such thio compounds are 1-acetyl-2-thiohydantoin and 3-butyl-5,5-dimethyl-2-thio-2,4-oxazolidinedione. Other suitable thio analogs of the foregoing acyl compounds are N-thiobenzoyl-2-pyrrolidone, N-thiopropionylmaleimide, N-phenyldithiosuccinimide, N-(n-octylcarbamyl)-2-thiopyrrolidone, etc.

To preclude the presence of large inert groups in the above-described N,N-diacyl promoters it is preferred that the molecular weight of the compound does not exceed about 1000 and more preferably still does not exceed about 500.

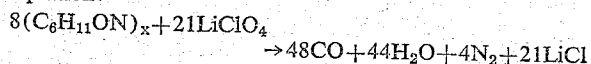
The process can be carried out at a temperature up to about 250° C. and preferably where the catalyst-promoter system is employed at temperatures up to about 190° C. and more preferably between about 130° C. to about 170° C. for the polymerization of ε-caprolactam in the presence of major amounts of lithium perchlorate and down to about 35° C. for the lower molecular weight lactams, e.g., pyrrolidone.

The amount of N,N-diacyl promoter employed in the polymerization process can vary from about 0.01 to about 5 mole percent of the lactam monomer and will preferably vary from about 0.01 to about 2 mole percent, and more preferably still from about 0.1 to 1 mole percent, the lower concentrations being used when a higher molecular weight polymer is desired.

When the solid propellant is produced by extrusion for insertion in small-bore rocket cases a small amount of the catalyzed-promoter system liquid polymer composition can first be added to the cylinder case such that the insertion of the extruded mass will displace the liquid polymer forcing it to rise in the annular space between the extrusion mass and the cylinder wall whereby the inserted mass is securely bonded within the case. The liquid polymer can be of similar composition to the propellant composition insert or any other suitable polymer composition which can be readily cured at temperatures below about 200° C., as for example polyurethanes, epoxy resins, polysulfide rubbers and the like.

When the lithium perchlorate-poly lactam propellant composition is cast in a casing either by the blend technique, or by polymerization casting, the rocket motor case can be lined with any suitable polymer composition and cured prior to loading with the fluid propellant composition. A core is placed in the fluid propellant composition which core is subsequently removed after the mass has solidified providing the desired internal cavity to effect proper radial burning of the propellant.

In general the weight ratio of the lithium perchlorate to the poly lactam will vary from about 2:1 to about 4:1 depending on the particular poly lactam employed and the various additives which may be incorporated therein. For example, the weight ratio of the lithium perchlorate to polycaprolactam should preferably be about 2.5:1 to oxidize the polycaprolactam according to the following equation:



Where more energy may be desired by oxidation of the carbon monoxide to carbon dioxide, up to 33 moles of the lithium perchlorate can be employed, i.e., up to about 3.875 parts by weight of lithium perchlorate per part of polycaprolactam. It will be understood that the presence of other additives may alter the aforesaid weight ratios.

The composite system lithium perchlorate-polycaprolactam for the weight ratio 2.47:1 was found to have a specific impulse of the order of about 250 sec. or higher at 1000 p.s.i. chamber pressure. In addition to this desirable relatively high specific impulse the system is also extremely valuable in that it also possesses a high volume impulse value. The combination of these two desirable properties makes the composite solid rocket propellants of this invention particularly valuable in high performance applications.

Also the novel lithium perchlorate-poly lactam compositions of this invention can contain various other components finely dispersed therein such as the finely divided light metals and various hydrides thereof, e.g., beryllium, boron, magnesium, aluminum, magnesium hydride, aluminum hydride, the various solid hydrides of boron such as decaborane, alkylated decaboranes (ethyl alkylated decaborane), aluminum borohydride, and the like. For example, the composite system lithium perchlorate-polycaprolactam for the weight ratio 2.47:1 may preferably contain up to about 20 percent by weight of the total composition of atomized aluminum (particle size about 20 microns). Preferably the aforesaid materials should be sufficiently fine to all pass a standard 100-mesh screen, and more preferably should pass a 200-mesh screen.

These light metal and metal hydride high-energy additives should preferably not exceed about 25 weight percent of the total composition. Notwithstanding the relatively high-energy content per unit of weight of the aforesaid additives, the heavy combustion exhaust tends to lower the performance of the solid propellant composition such that it is often desirable to incorporate not more than from 5 to about 10 weight percent of said additive, based on the total weight of the propellant composition.

Another class of additives which can be incorporated in the lithium perchlorate-poly lactam compositions are the relatively low molecular weight plasticizers, for example, the sulfonamides such as N-monosubstituted toluenesulfonamides, e.g. N-ethyl-p-toluenesulfonamide, N-ethyl-o-toluenesulfonamide and mixtures thereof; disubstituted amides such as dimethyl formamide; and glycol ethers such as triethylene glycol dimethyl ether; butyrolactone; ethylene glycol; and the like. The fairly polar plasticizers preferably should also be solvents for the lithium perchlorate such that the components of the system are mutually soluble or dispersible to effect a homogeneous solid composition. The presence of the plasticizer in the noncrystalline poly lactam renders the composition more rubbery and provides a material improvement in the tensile elongation of the material. These composite compositions are characterized by their ability to provide a good seal between the solid propellant and the rocket motor case, which insures proper radial burning of the propellant without overheating the rocket motor case. The plasticizer employed also functions as a fuel element in the composite solid propellant and the ratio of the lithium perchlorate is adjusted such that a proper balance is maintained between the oxidant and the fuel combinations to provide complete combustion. The amount of plasticizer employed can vary up to about 35 weight percent of the poly lactam present in the composition, but amounts of from about 15 to about 25 weight percent are generally preferred.

The lithium perchlorate-poly lactam compositions of the invention are useful as a solid propellant for rockets including short-range ballistic weapons, such as aircraft and artillery rockets, and long-range strategic missiles, wherein they may be the sole propellant or be employed

in one or more stages of a multistage rocket system. The aforesaid compositions are also useful for rocket assisted takeoff and as boosters and sustainers. The lithium perchlorate-poly lactam compositions of this invention can be drawn into fibers and cords which can be employed as a fuse, and the said compositions are also useful as pyrotechnics. When confined the aforesaid compositions also are particularly valuable as explosives.

The lithium perchlorate-poly lactam compositions of this invention burn vigorously and very uniformly when ignited. They are also exceptionally stable to shock and heat. Thus it was demonstrated that small pieces of the lithium perchlorate-polycaprolactam composition could be hammered repeatedly on a steel anvil without detonation. Excellent thermal stability was demonstrated by heating a sample of the aforesaid composition at 300° C. for 2.5 hours without ignition.

The following examples are illustrative of this invention:

Example 1

A mixture of 2.5 parts by weight of lithium perchlorate per part by weight of polycaprolactam was prepared by blending in a ball mill. Then the mixture was heated to a temperature of 190° C. and the two components melted down to give a transparent viscous material. The cooled material was a tough and horny product which appeared very homogeneous. On ignition the product burned vigorously with a smooth continuous flame.

Example 2

A blend of about 4 parts by weight of lithium perchlorate per part by weight of polycaprolactam was prepared by heating the materials together at 240° C. The two components gave a homogeneous melt which solidified to a tough, somewhat flexible product. On ignition the product burned with an intense, uniform flame.

Example 3

A mixture of lithium perchlorate, polycaprolactam and aluminum powder was heated together in a weight ratio of 625:125:212, respectively, at 240° C. A paste was formed at this temperature and on cooling a hard, cement-like product was obtained. This product burned easily on ignition.

Example 4

A mixture of lithium perchlorate, polycaprolactam and magnesium hydride was heated together in a weight ratio of 625:125:227, respectively, at 240° C. Upon cooling a white cement-like material was obtained. The product burned very smoothly on ignition.

Example 5

To 2.47 parts by weight of anhydrous lithium perchlorate at 160° C. was added 1 part by weight of ϵ -caprolactam containing 0.002 part by weight of a 50% dispersion of sodium hydride in mineral oil. Then 0.016 part by weight of N-acetyl caprolactam was added thereto and the homogeneous mixture held at 160° C. for about 2 hours to effect polymerization. The solid homogeneous composite was ignited at room temperature and found to burn vigorously and smoothly.

Example 6

One part by weight of caprolactam was added to 2.5 parts by weight of anhydrous lithium perchlorate at a temperature of about 180° C. and the mixture was stirred to aid the solution of the perchlorate in the monomer. Then 0.012 part by weight of N-acetyl caprolactam and 0.05 part by weight of a 3 molar solution of phenyl magnesium bromide were added to the mixture and stirred to effect a uniform distribution of the initiator and catalyst in the said mixture. It was noted that there was an increase in viscosity of the system within three minutes. The composition was held at about 180° C. for a time of about 3 hours and then cooled. The homogeneous

lithium perchlorate polycaprolactam composition was easily ignited with a flame and burned vigorously and smoothly.

Example 7

A composite blend was prepared by heating together 2.5 parts by weight of lithium perchlorate, 0.8 part by weight of polycaprolactam, and 0.2 part by weight of triethylene glycol dimethyl ether at 240° C. The fluid, homogeneous composition was easily stirrable. After cooling it was found that this composite composition had considerable elasticity and fibers prepared therefrom could be easily stretched more than 100 percent before breaking.

Example 8

A composite blend was prepared by heating together 3.33 parts by weight of lithium perchlorate, 1 part by weight of polycaprolactam, and 0.44 part by weight of ethylene glycol to a temperature of 220° C. until a homogeneous composition was obtained. Then the composite blend was cooled and found to be a rubbery composition which could be stretched and deformed and rolled or reformed into new shapes. This composite blend burned vigorously and smoothly when ignited.

Example 9

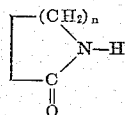
A composite blend was prepared by heating together 2.5 parts by weight of lithium perchlorate, 0.75 part by weight of polycaprolactam, and 0.34 part by weight of butyrolactone to a temperature of 220° C. with stirring to effect a homogeneous melt. The composition was cooled to room temperature and found to be a leathery product which burned vigorously and smoothly when ignited.

The molecular weight of the poly(lactam) should preferably be above about 10,000 and below about 75,000 to enable proper blending with the lithium perchlorate and other additives. A particularly desirable range of molecular weight of the poly(lactam) for this purpose is from about 10,000 to about 40,000. It will be understood that when the case-polymerization system is employed the molecular weight of the polymer in the composite is of less importance, but must of course be sufficiently high to provide a solid composite composition under temperatures to which the material may be exposed prior to firing. Accordingly, a molecular weight of at least about 10,000 should be effected in the cast-polymerization process of preparing composite compositions for solid rocket propellants.

We claim:

1. A composition of matter consisting essentially of a substantially homogeneous solid solution of lithium perchlorate and a poly(lactam) in a weight ratio of from about 2:1 to about 4:1, wherein the lactam monomer for the said poly(lactam) contains from 4 to 6 carbon atoms in the lactam ring.

2. A composition of matter consisting essentially of a homogeneous solid solution of lithium perchlorate and a poly(lactam) in a weight ratio of from about 2:1 to about 4:1 and the said poly(lactam) is obtained by the polymerization of lactams defined by the structural formula:



wherein n is an integer from 3 to 5, inclusive.

3. A composition of matter consisting essentially of a homogeneous solid solution of lithium perchlorate and polycaprolactam in a weight ratio of from about 2:1 to about 4:1.

4. A composition of matter consisting essentially of a substantially homogeneous mixture of lithium perchlorate and polycaprolactam in a weight ratio of from about 2:1 to about 4:1.

5. The composition of matter of claim 4, wherein the weight ratio is about 2.5:1.

6. A composition of matter consisting essentially of a substantially homogeneous solid solution of lithium perchlorate and a poly(lactam) in a weight ratio of from about 2:1 to about 4:1, wherein the lactam monomer for the said poly(lactam) contains from 4 to 6 carbon atoms in the lactam ring, and uniformly dispersed therein up to about 25 percent, by weight of the total composition, of a high-energy additive selected from the group consisting of beryllium, boron, magnesium, aluminum, magnesium hydride, aluminum hydride, aluminum borohydride, decaborane, alkylated decaborane, and mixtures thereof.

7. A composition of matter consisting essentially of a substantially homogeneous solid solution of lithium perchlorate and polycaprolactam in a weight ratio of from about 2:1 to about 4:1, and uniformly dispersed therein up to about 25 percent, by weight of the total composition, of a high-energy additive selected from the group consisting of beryllium, boron, magnesium, aluminum, magnesium hydride, aluminum hydride, aluminum borohydride, decaborane, alkylated decaborane, and mixtures thereof.

8. The process of preparing a substantially homogeneous composition of lithium perchlorate and a poly(lactam), wherein the lactam monomer for the said poly(lactam) contains from 4 to 6 carbon atoms in the lactam ring, comprising heating a mixture of lithium perchlorate and a poly(lactam) in a weight ratio of from about 2:1 to about 4:1 to a temperature up to about 250° C. until a substantially homogeneous solution is obtained and thereafter casting the fluid composition and allowing it to solidify.

9. The process of claim 8, wherein the poly(lactam) is polycaprolactam and the temperature employed is from about 150° C. to about 250° C.

10. The process of preparing a substantially homogeneous composition of lithium perchlorate and a poly(lactam) comprising the polymerization of lactam monomer containing from 4 to 6 carbon atoms in the lactam ring in the presence of from about 2 to about 4 parts by weight of anhydrous lithium perchlorate, per part by weight of monomer, and effecting polymerization of said monomer by the presence of a base-catalyst in the amount of from about 0.05 to about 5 weight percent, based on the monomer, and from about 0.01 to about 5 mole percent, based on the monomer, of an N,N-diacyl promoter compound having a tertiary nitrogen atom and having at least two of the three N-substituents selected from the group consisting of carbonyl, thiocarbonyl, sulfonyl and nitroso radicals.

11. The process of claim 10, wherein the base catalyst is present in the amount of from about 0.1 to about 1 weight percent, and the promoter is present in the amount of from about 0.1 to about 1 mole percent.

12. The process of claim 11, wherein the monomer is ϵ -caprolactam.

13. The process of claim 12, wherein the polymerization process is carried out at a temperature below about 190° C.

14. The process of claim 13, wherein the base-catalyst is sodium hydride and the promoter is N-acetyl caprolactam.

15. The process of claim 13, wherein the base-catalyst is lithium hydride and the promoter is N-acetyl caprolactam.

16. The process of claim 13, wherein the lithium perchlorate is present in a weight ratio of about 2.5 times that of the caprolactam.

17. The process of claim 11, wherein the monomer is pyrrolidone.

18. The process of preparing a solid rocket propellant comprising the process of claim 10, wherein up to 25 percent, by weight of the total composition, of a high-energy

additive selected from the group consisting of beryllium, boron, magnesium, aluminum, magnesium hydride, aluminum hydride, aluminum borohydride, decaborane, alkylated decaborane, and mixtures thereof is uniformly dispersed therein in a finely divided form and maintained in a substantially uniform dispersion by mild agitation until the polymer is advanced to a viscosity which retains said group of metals and hydrides thereof in a substantially uniform dispersion and thereafter completing the polymerization of the monomer at a temperature below about 190° C.

19. The process of claim 18, wherein the monomer is ϵ -caprolactam.

20. The composition of matter of claim 1 having uniformly dispersed therein in a finely divided form a minor amount of aluminum.

21. The composition of matter of claim 1 having uniformly dispersed therein in a finely divided form a minor amount of boron.

22. The composition of matter of claim 1 having uniformly dispersed therein in a finely divided form a minor amount of magnesium.

23. The composition of matter of claim 1 having uniformly dispersed therein in a finely divided form a minor amount of magnesium hydride.

24. The process of preparing a solid rocket propellant composition comprising the process of claim 10, wherein up to 25 percent, by weight of the total composition, of finely divided aluminum is uniformly dispersed therein and maintained in a substantially uniform dispersion by mild agitation until the poly lactam is advanced to a viscosity which retains the powdered aluminum in a substantially uniform dispersion and thereafter completing the polymerization of the monomer at a temperature below about 190° C.

25. The process of preparing a solid rocket propellant composition comprising the process of claim 10, wherein up to 25 percent, by weight of the total composition, of finely divided boron is uniformly dispersed therein and maintained in a substantially uniform dispersion by mild agitation until the poly lactam is advanced to a viscosity

which retains the powdered boron in a substantially uniform dispersion and thereafter completing the polymerization of the monomer at a temperature below about 190° C.

26. The process of preparing a solid rocket propellant composition comprising the process of claim 10, wherein up to 25 percent, by weight of the total composition, of finely divided magnesium is uniformly dispersed therein and maintained in a substantially uniform dispersion by mild agitation until the poly lactam is advanced to a viscosity which retains the powdered magnesium in a substantially uniform dispersion and thereafter completing the polymerization of the monomer at a temperature below about 190° C.

27. The process of preparing a solid rocket propellant composition comprising the process of claim 10, wherein up to 25 percent, by weight of the total composition, of finely divided magnesium hydride is uniformly dispersed therein and maintained in a substantially uniform dispersion by mild agitation until the poly lactam is advanced to a viscosity which retains the powdered magnesium hydride in a substantially uniform dispersion and thereafter completing the polymerization of the monomer at a temperature below about 190° C.

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