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[54] **COMPOSITE PROPELLANT CONTAINING POLYTETRAFLUOROETHYLENE POWDER AND BUTYL OR ETHYLENE-PROPYLENE RUBBER**

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[51] **Int. Cl.** **C06d 5/06**

[58] **Field of Search** 149/19, 76, 44, 19.3, 19.91, 149/20

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[57] **ABSTRACT**

A process for the preparation of propellant molding powders having good ingredient quality control and good composition homogeneity comprising Teflon powder, butyl or ethylene-propylene rubber binder and an inorganic oxidizer. Metal fuels such as aluminum were also included, as were burning rate modifiers. The process comprises forming a homogeneous binder solution, adding the propellant ingredients and mixing to form a paste, extruding the paste through small cross-sectional orifices, blowing warm air or inert gas around the strands extruded from the orifices and collecting the strands by appropriate means.

7 Claims, No Drawings

COMPOSITE PROPELLANT CONTAINING POLYTETRAFLUOROETHYLENE POWDER AND BUTYL OR ETHYLENE-PROPYLENE RUBBER

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

The present invention relates to improved homogeneous propellant molding powder and to the process for preparation thereof.

For some time in the propellant field work has been directed toward devising and providing a versatile family of propellants to meet the future needs of the rocket system developers. The hydrocarbon-rubber binder systems now in use are highly unsaturated and are the major cause of chemical instability of the propellant grain. Chemical stability is important since chemical changes that affect the performance may occur during storage in uncontrolled environments. Moreover, the techniques by which they are used may introduce various process variables which prevent ballistic reproducibility. The present invention is for propellant powders which are highly homogeneous. The process eliminates a quality control problem, enhances reliability in regard to those features which are affected by homogeneity, and eliminates a potential safety hazard caused by free oxidizer.

DESCRIPTION OF THE INVENTION

In accordance with the present invention from about 50 to 70 percent by weight inorganic oxidizer and 10 to 20 percent by weight metal fuel were incorporated into a matrix comprising from about 2 to 10 percent by weight polytetrafluoroethylene (Teflon) and from about 5 to 10 percent by weight butyl or ethylene propylene rubber to form a paste. The paste was extruded through small cross-sectional area orifices producing strands of the formulation around which a high volume of warm air or inert gas was circulated by blowing means and the strands collected on conveyor belts or other means, followed by complete drying or curing under ambient conditions.

The matrix is prepared by mixing the selected rubber, butyl and/or ethylene-propylene, in a solvent such as petroleum ether which is preferred. However, hexane works satisfactorily with the ethylene-propylene rubbers. Butyl rubber is highly impermeable (a very desirable feature) and holds tenaciously to the solvent.

Propellant strands prepared by this process are highly homogeneous. The strands show no oxidizer on the surface and no material is segrated. Nothing is selectively lost by adherence to the mixing kettle, as often occurs in the well known shock-precipitation method of producing molding powders. The present process eliminates a quality control problem, enhances reliability in regard to those features which are affected by homogeneity, and eliminates a potential safety hazard caused by free oxidizer.

This process contrasts with the old, but frequently used process for compounding propellant powders which involves preparing a solution of the soluble binder material, suspending the solid components in the solution, and precipitating the binder by quenching with a nonsolvent. The agglomerated mixture of ingredients is separated from the supernatant liquids, and then dried, and sometimes screened. Although this is often called a coating process, it is in fact a simple agglomeration with solid particles randomly and mechanically held in a matrix of binder material. Often by this process, old in the art, ammonium perchlorate, the most widely used oxidizer, dissolves or recrystallizes in polar solvents which contain water resulting in changes in oxidizer particle size distribution in the final product.

In the present invention with the rubber based propellant formulations Teflon is used as a reinforcing agent. Teflon will, during a shearing procedure, coalesce and cold draw into fibers. Thus, with the Teflon powder-rubber mixture, the conventional extrusion procedure results in the formation of reinforcing fibers in situ. All the fibers are never really completely straight, for there is a certain amount of sideways drift of particles during extrusion. Teflon content as low as ½% effectively improves the tensile strength and % elongation of propellants containing it. The strength increases as the Teflon content is increased.

Several hundred measurements have been made on 0.125-inch diameter strands of the extruded mixed-binder (i.e., Teflon/rubber) propellants. The tensile strengths were generally in the range 300 to 800 psi and the percent elongations in the range of 20 to 35%.

In general the burning rates of these propellants measured with 0.125-inch diameter strands are about 0.5 in/sec at 1000 psi and ambient temperature. Slopes vary from 0.45 to 0.70 with butyl rubber, and from 0.6 to 0.8 with ethylene propylene rubber.

The following examples in Table I below present motor firing data for the mixed binder extruded propellants formulated as follows:

TABLE I

Ex.	Propellant Formulation Ingredients	Wt. %	Theoretical I_{sp} sec	Theoretical Density lb/in³	Measured I_{sp} sec	Measured Density lb/in³	Efficiency %
1	Butyl rubber	8	264.3	0.068	237.0	0.067	89.6
	Teflon	2					
	Ammonium perchlorate	70					
	Aluminum	20					
2	Butyl rubber	9	264.0	0.068	232.0	0.066	87.9
	Teflon	3					
	Ammonium perchlorate	68					
	Aluminum	20					
3	Butyl rubber	6	260.5	0.070	233.0	0.068	89.4
	Teflon	7					
	Ammonium perchlorate	70					
	Aluminum	17					

TABLE I – Continued

Ex.	Propellant Formulation Ingredients	Wt. %	Theoretical I_{sp} sec	Theoretical Density lb/in³	Measured I_{sp} sec	Measured Density lb/in³	Efficiency %
4	Butyl rubber	7	242.0	0.066	227.0	0.065	93.8
	Teflon	16					
	Ammonium perchlorate	77					

Strand burning rates at 77° F. and 1,000 psi of three of the present new formulations are given below:

TABLE II

Propellant Composition (% by weight)				Rate (in/sec)	Slope Δ rate/ Δ pressure
Butyl	Teflon	Al	AP		
8.0 Ethylene-propylene	.0	19.0	70.0	0.48	0.49
10.0	.0	17.5	72.5	0.50	0.81
8.5	3.5	16.0	72.0	0.41	0.87

In Table III hereinbelow the theoretical performance is given of a number of propellants prepared as herein disclosed:

TABLE III

THEORETICAL PERFORMANCE OF NEW PROPELLANTS

Composition, %				Ballistics			
Butyl	Teflon	Al	AP	I_{sp}	ρ	ρI_{sp}	Chamber Temp., °F
12	0	0	88	248	1.72	427	4,813
12	0	2	86	251	1.73	433	4,928
12	0	8	80	258	1.75	452	5,269
12	0	10	78	260	1.76	458	5,376
12	5	10	73	256	1.77	454	5,197
10	0	0	90	252	1.75	442	4,968
10	5	2	83	251	1.77	444	5,026
10	5	4	81	253	1.78	450	5,150
10	0	6	84	258	1.78	460	5,381
10	5	6	79	255	1.79	456	5,268
10	5	10	75	259	1.80	467	5,490
10	3	15	72	263	1.83	480	5,796
10	3	17	70	264	1.84	484	5,880
9	3	15	73	263	1.85	485	5,915
9	4	17	70	263	1.86	488	5,975
9	3	19	69	264	1.87	493	6,084
9	4	20	67	264	1.87	494	6,079
8	15	0	77	243	1.82	441	4,857
8	5	2	85	253	1.81	457	5,097
8	10	2	80	250	1.82	454	5,072
8	5	4	83	255	1.82	463	5,270
8	5	6	81	257	1.83	469	5,422
8	4	15	73	262	1.87	489	5,992
8	4	17	71	263	1.88	493	6,088
8	3	17	72	263	1.88	493	6,113
8	3	19	70	264	1.89	497	6,202
8	2	20	70	264	1.89	499	6,271
8	4	20	68	264	1.89	499	6,208
7	5	15	73	261	1.90	497	6,055
7	6	17	70	261	1.90	497	6,137
7	15	19	59	257	1.93	496	5,888
6	15	2	77	248	1.86	462	5,033
6	10	6	78	254	1.87	476	5,405
6	7	17	70	261	1.93	501	6,201
5	7	17	71	259	1.95	505	6,262

Burning rate modifiers were incorporated into the formulations and strand burning rate results were made at 77° F. and 1,000 psi. Up to 3% modifier selected from the group consisting of cuprous oxide, cupric oxide, copper chromate and ferric oxide were used. The following is a typical example:

Ingredients	Percent by weight
Butyl rubber	8
Teflon	3
Aluminum	19
Ammonium perchlorate	70
Copper chromate	3

Butyl rubber was mixed into the solvent, petroleum ether, to which Teflon, aluminum and ammonium perchlorate crystals (in a ratio of 1:1 as received, 190μ average diameter, and ground 8μ average diameter) were blended to form a paste. The paste was extruded into burning rate strands from which the following data was derived: burning rate, 0.98 in/sec, slope Δ rate/Δ pressure 0.53.

Butyl rubber used herein is a synthetic rubber produced by polymerizing isobutylene or alternatively by copolymerization of isobutylene (approximately 98%) with a small proportion (2%) of conjugated diene, for instance isoprene or butadiene, and is identified more specifically as isobutylene-isoprene rubber (IIR). The ethylene-propylene rubber (EPR) is an elastomer made by the steriospecific copolymerization of ethylene and propylene and alternatively a small percent, 2 – 5%, of a conjugated diene is added to provide curing sites.

What is claimed is:

1. A propellant molding powder comprising:
from about 70 to 90 percent by weight inorganic oxidizer;
up to about 20 percent by weight polytetrafluoroethylene; and
from about 5 to about 15 percent by weight of a synthetic rubber selected from the group consisting of butyl rubber, ethylene propylene rubber and mixtures thereof.

2. The powder in accordance with claim **1** wherein the oxidizer is ammonium perchlorate.

3. The powder in accordance with claim **1** containing additionally up to about 20 percent by weight metallic fuel.

4. The powder in accordance with claim **3** containing additionally up to about 3 percent burning rate modifier.

5. The powder in accordance with claim **3** wherein the fuel is aluminum.

6. The powder in accordance with claim **5** wherein the oxidizer is ammonium perchlorate.

7. The powder in accordance with claim **4** wherein the oxidizer is ammonium perchlorate, the fuel is aluminum and the burning rate modifier is copper chromate.

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