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**McBride et al.**

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[54] **PROPELLANT COMPOSITION**


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[52] **U.S. Cl.** ..... **149/19.5;** 149/2; 149/19.9; 149/76; 149/113

[51] **Int. Cl.²** ..... **C06P 45/10**

[58] **Field of Search** ..... 149/2, 17, 113, 21, 76, 149/19.5, 19.9; 264/3 R



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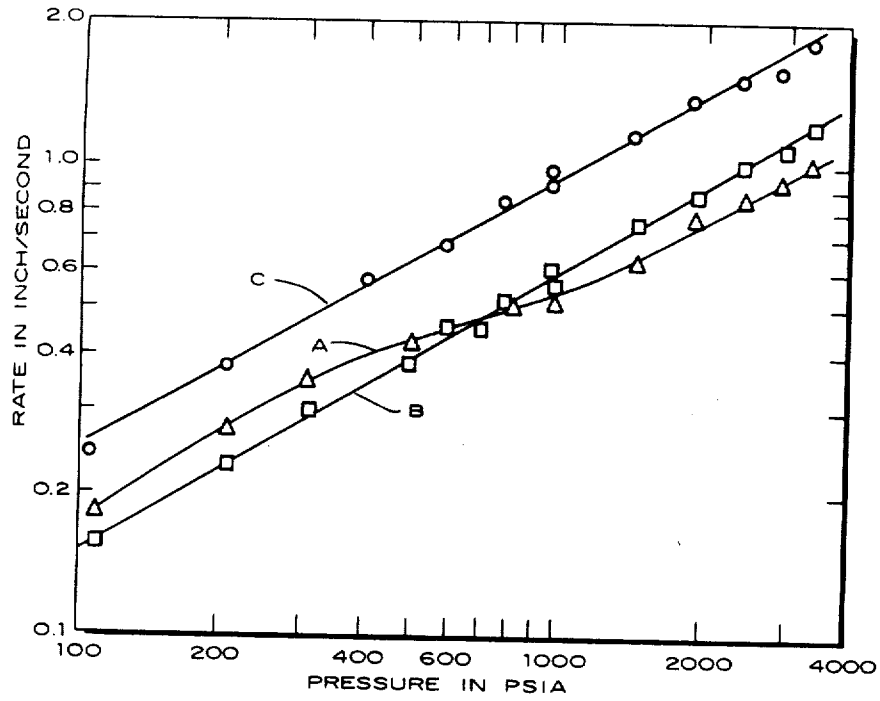
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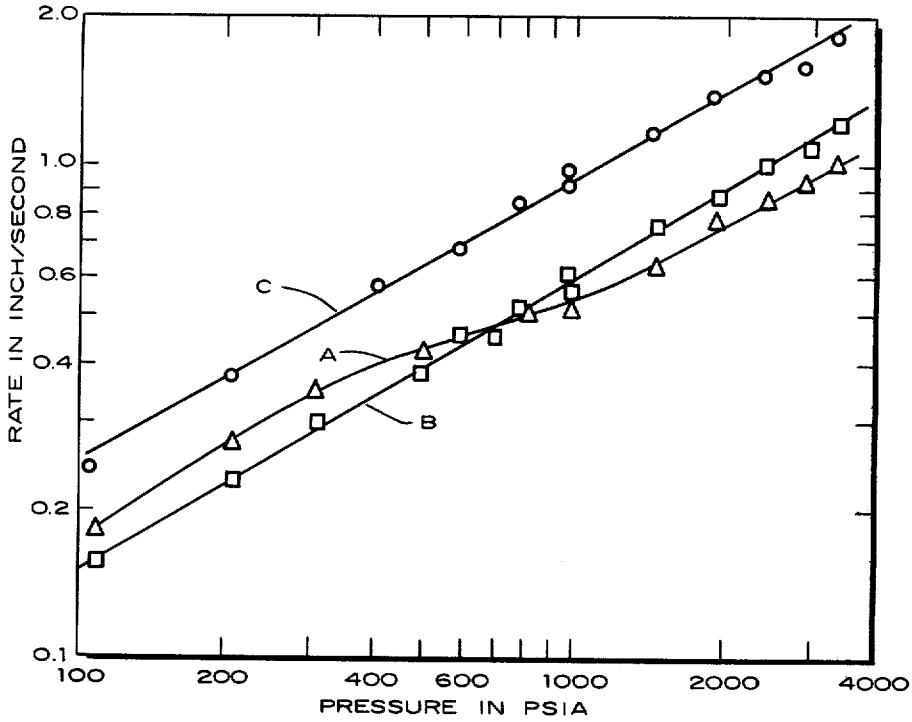


[57] **ABSTRACT**

A solid composite propellant composition consisting essentially of a conventional binder containing modified ammonium perchlorate which consists of whisker-like single crystals without inclusions and ranging in diameter from about 1 to 40 microns.


**4 Claims, 1 Drawing Figure**






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# PROPELLANT COMPOSITION

## 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 invention relates to improved solid propellants, and more particularly to a composite propellant formulation containing modified ammonium perchlorate crystals.

As a result of the need in modern rocket technology greater refinement in the development of solid propellants has become necessary. More powerful rocket ingredients are constantly being sought to provide improved environmental resistant qualities, improved physical properties, better and unique burning rate characteristics, and to yield improved thrust-time characteristics. The present invention utilizes a modified form of ammonium perchlorate crystals which provides improved physical and chemical properties over compositions using regular grind ammonium perchlorate crystals.

## BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE is a graph which summarizes and compares the burning rates for the propellant strands of propellant formulations containing commercially ground ammonium perchlorate, nominal 40-$\mu$ whisker ammonium perchlorate and nominal 3-$\mu$ whisker ammonium perchlorate.

## BRIEF DESCRIPTION OF THE INVENTION

Broadly speaking, the present invention resides in a composite propellant composition comprising a conventional propellant binder and modified ammonium perchlorate cystals in the form of whiskers having a length to diameter ratio of about 5:1 to about 100:1. Other conventional constituents have been incorporated, such as ballistic modifiers.

The conventional composite propellant binders include functional polybutadienes such as hydroxy or carboxyterminated polybutadiene polymers, butadiene acrylic acid copolymers, butadiene acrylic acid acrylonitrile terpolymer, polyesters, polysulfides, polyurethanes, plastisols, etc. Other conventional constituents include metals such as aluminum and magnesium, metal organic compounds, metallic hydrides, and various ballistic modifiers, such as iron oxide, potassium perchlorate, and potassium dichromate.

Ammonium perchlorate whiskers used in the examples herein were nominal 40-$\mu$ diameter and nominal 3-$\mu$ diameter size. The larger diameter whiskers were prepared by feeding ammonium perchlorate solution below saturation through commercially available porous glass tubes. The nominal 3-$\mu$ diameter whiskers were formed by the process described in copending patent application Ser. No. 79,680 filed Oct. 9, 1970, which comprises feeding ammonium perchlorate solution through porous glass tubing which is carefully and thinly coated on the outside with silicone adhesive. Whiskers of varying size prepared by other means may be used.

The following examples illustrate the present invention:



EXAMPLE I

| Ingredients | % by weight |
|---|---|
| Carboxyterminated polybutadiene prepolymers (CTPB) | 24 |
| Ammonium perchlorate (nominal 40$\mu$) | 76 |

The ammonium perchlorate crystals used herein are characterized as being whisker-like orthorhombic single crystals without inclusions and having a length to diameter ratio of from about 5:1 to about 100:1. They were blended into the carboxyterminated polybutadiene prepolymer in a conventional mixer to form a homogenous mixture which was cast and cured into predetermined shapes and tested. Samples of this formulation were also cast into burning rate strands, sections of which were cut parallel and perpendicular to the direction of extrusion to determine the whisker oxidizer orientation. At right angles to the direction of extrusion many of the crystals showed triangular cross-section, and a cut parallel to the direction of extrusion showed a columnar structure of the whiskers in the propellant.

EXAMPLE II

| Ingredients | % by weight |
|---|---|
| Carboxyterminated polybutadiene prepolymer | 20 |
| Ammonium perchlorate (nominal 3$\mu$) | 64 |
| Aluminum (nominal 15$\mu$) | 16 |

The above ingredients were processed as in Example I, and the mixture cast into preforms, cured and tested. A sample was thinned after mixing and prior to cure and dispersed sufficiently for optical examination under the microscope. It was noted that although the whiskers were broken during mixing, a length to diameter ratio ranging from 5:1 and 10:1 was maintained.

EXAMPLE III

| Ingredients | % by weight |
|---|---|
| Carboxyterminated polybutadiene prepolymer | 24 |
| Ammonium perchlorate (nominal 3$\mu$) | 76 |

The ingredients were processed as described herein and cast into burning rate strands. The strands were individually connected to appropriate ignition and timing circuits and burned. The burning time and temperature were recorded and the burning rates were calculated and plotted on logarithmic paper.

A propellant formulation containing 15$\mu$ commercially ground ammonium perchlorate was prepared as follows for comparison of its burning rate characteristics with the new formulations containing the whisker ammonium perchlorate.

EXAMPLE IV

| Ingredients | % by weight |
|---|---|
| Carboxyterminated polybutadiene prepolymer | 24 |
| Ammonium perchlorate (15$\mu$ grind) | 76 |

The ingredients were blended together in a conventional mixer and the homogeneous paste resulting therefrom was cast into burning rate strands. The strands were burned in the manner described hereinabove and burning times and temperatures were re-

corded and the burning rates were calculated and plotted.

In the single FIGURE in the form of a graph there is shown comparative burning rates for propellant strands comprising the formulation (Example IV) containing 15-$\mu$ commercial grind ammonium perchlorate designated curve A; the formulation (Example I) containing nominal 40-$\mu$ whisker ammonium perchlorate, designated curve B; and formulation (Example III) containing nominal 3-$\mu$ whisker ammonium perchlorate, designated curve C. A sigmoid curve for the ground ammonium perchlorate formulation (Example IV) is observed. All data acquired with the whisker formulations conform to the simple expression $r = aP_c^n$ (absence of sigmoid shape) where $r$ is the burning rate, $a$ is a constant, $P_c$ is the pressure and $n$ is the pressure exponent. The pressure exponents for curves B and C are 0.584 and 0.567, respectively. The difference in burning rates for curves B and C is attributed to the difference in effective particle size of the whisker ammonium perchlorate of the two formulations.

The comparison illustrates that the whisker ammonium perchlorate incorporated into a propellant formulation provides burning rates which conform to the simplified linear rate equation and its resultant linear regression as plotted and shown in the single FIGURE. (Ground ammonium perchlorate gives a sigmoid burning rate pressure curve). The pressure exponent for the log rate vs. log pressure plot is constant, approximately 0.58. The burning rate of the propellant is apparently controlled by the diameter of the whiskers in that the rate increases with a decrease from 40-$\mu$ to 3-$\mu$ nominal whisker diameter. Although mixing the propellant formulation reduces the length-to-diameter ratio of the whiskers, the material is still capable of being oriented with an extrusion process.

Catalyzed ammonium perchlorate whiskers prepared by the process described in copending patent application Ser. No. 79,680 filed Oct. 9, 1970 referenced hereinbefore were also incorporated into conventional composite propellant binders. Predetermined amounts of catalytic materials incorporated into the ammonium perchlorate whiskers included such burning rate modifiers as potassium perchlorate, ammonium permanganate, ammonium dichromate and iron oxide. Any burning rate modifier having ions which can be incorporated into the ammonium perchlorate crystals can be used. Several batches of propellant formulation comprising about 25 percent by weight carboxyterminated polybutadiene prepolymer and about 75 percent catalyzed ammonium perchlorate whiskers were prepared, cast and cured. Some was extruded into burning rate strands and routinely tested. They showed unusual combustion properties such as higher burning rate exponent, were difficult to ignite and sustain burning at low pressure.

Both the ammonium perchlorate whiskers and the catalyzed ammonium perchlorate whiskers of micron and submicron diameter can be used in conjunction with a large variety of binders and fuels to produce an improved solid composite propellant grain.

What is claimed is:

**1.** A solid propellant formulation comprised of an oxidizer phase consisting of whisker-like crystals of ammonium perchlorate in combination with at least one solid propellant binder selected from the group consisting of hydroxy terminated polybutadiene, carboxy terminated polybutadiene butadiene acrylic acid copolymers, butadiene acrylic acid acrylonitrile terpolymer, polyesters, containing constituents selected from the group consisting of metals, metal organic compounds, metallic hyclrides, ballistic modifiers and combinations thereof.

**2.** The formulation in accordance with claim **1** wherein said whisker-like crystals are of varying dimensions ranging in a length to diameter ratio of from about 5:1 to about 100:1.

**3.** The formulation in accordance with claim **1** wherein said oxidizer phase consists of

catalyzed ammonium perchlorate whiskers which consist essentially of ammonium perchlorate and a predetermined amount of a burning rate modifier.

**4.** The formulation in accordance with claim **3** wherein said burning rate modifier is a member selected from the group consisting of potassium perchlorate, ammonium permanganate, ammonium dichromate and iron oxide.

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