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1

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PLASTIC PYROTECHNIC COMPOSITIONS CONTAINING STRONTIUM PERCHLORATE AND ACRYLIC POLYMER

Bernard E. Douda, Bloomfield, Ind., assignor to the United States of America as represented by the Secretary of the Navy

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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.

The present invention relates to plastic pyrotechnic compositions and more particularly to plastic pyrotechnic composition that are pour castable and upon solidification form pyrotechnics that are long burning.

Heretofore, one method of manufacturing pyrotechnic articles consisted of filling a hollow tube or container with a combustible mixture in powder form and then subjecting the mixture to a very high pressure. The resulting product has a density depending upon various conditions such as the type of mixture and the amount and duration of the pressure applied. Such pyrotechnic articles show wide variations in their rate of combustion.

In order to overcome the disadvantages of compacted pyrotechnic articles, recent developments in the pyrotechnic art has produced various plastic type compounds that can be cast or molded. One such plastic compound is described in U.S. Patent 2,984,558, which issued May 16, 1961, to Edward Rolle and John Q. Tabor. This patented compound is essentially a mixture of unsaturated polyester resins to which is added a stabilizing ingredient, oxidizers, and a fuel.

In the present invention strontium perchlorate is added to an acrylic monomer. The portion of the strontium perchlorate that dissolves in the acrylic monomer acts as an activator to prepolymerize the acrylic monomer. The undissolved strontium perchlorate remains suspended in solid form in the prepolymerized acrylic monomer. Various fuels, oxidizing agents, and coloring agents are next added to the partially polymerized monomer, and a catalyst is then added to facilitate complete polymerization.

It is therefore a general object of the present invention to provide an improved pyrotechnic material which may be readily cast or molded.

Another object of the present invention is to provide a pyrotechnic material which has an essentially constant rate of burning.

A further object of the present invention is to provide a long burning colored flare that can be readily manufactured.

Other objects and advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following description.

It has been found that strontium perchlorate will dissolve in acrylic monomers, such as the esters of acrylic and methacrylic acids. At room temperature, about 18 parts of anhydrous strontium perchlorate will dissolve in 100 parts of methyl methacrylate monomer. It has been discovered, however, that the degree of solubility is related to the amount of moisture contained in the oxidant. Maximum solubility occurs when about 2.2 percent of moisture is present in the oxidant. Upon mixing the desired amount of oxidant with the acrylic monomer, prepolymer is readily formed, accompanied by heat evolution. This results in an increase in viscosity of the mixture. This reaction occurs without the need of an organic catalyst, and if the process is not regulated as to the degree of solubility and temperature, a hard polymeric mass will be formed. From a production standpoint, this prepolymerization feature is an asset for because of the increase in density and viscosity of the monomer other insoluble ingredients will remain suspended in the viscous blended mass without appreciable settling prior to polymerization.

2

The strontium perchlorate acts both as an activator and a catalyst in that small amounts of strontium perchlorate when added to an acrylic monomer, will shorten the induction time normally required to polymerize the monomer, and also the temperature required to polymerize the monomer is less. When the strontium perchlorate dissolves in the monomer, there is provided a solution which serves both as a fuel and an oxidizing agent.

The following examples are illustrative of the invention. In each of the examples, the monomer used was methyl methacrylate that was inhibited with 25 p.p.m. hydroquinone, however, it should be understood, of course, that other esters of acrylic acid and methacrylic acid will work equally as well.

Example I

50 ml. of methyl methacrylate monomer
165 gms. of strontium perchlorate
3 drops of cumene hydroperoxide

The ratio, by weight, of monomer to strontium perchlorate is about 1 to 3.5. The mixture was heated in an oven for 12 hours at a temperature of 75 degrees C. A candle was prepared in a fish paper tube having an inside diameter of 1.76 inches, and a two-inch candle burned for 30 seconds. The flame was about 24 inches high and very bright red in color. A white smoke was produced and there was almost no ash.

Example II

45 ml. of methyl methacrylate monomer
35 gms. of strontium perchlorate
30 gms. of magnesium (atomized)
45 gms. of anhydrous strontium oxalate
10 gms. of anhydrous strontium chloride
¼ drop of Lupersol DDM (a solution of 60% methylethylketone peroxide in dimethylphthalate)

The ratio, by weight, of monomer to strontium perchlorate is 1 to 0.83. The mixture was heated in an oven for 24 hours at a temperature of 75 degrees C. A candle was prepared as in Example I, and the burning time was 95 seconds. The flame was about 12 inches high and very bright red in color. The magnesium was used as a fuel; the strontium chloride as a coloring agent; and the strontium oxalate as a coloring agent and burning time regulator.

Example III

50 ml. of methyl methacrylate monomer
50 gms. of strontium perchlorate
50 gms. of magnesium (atomized)
20 drops of Lupersol DDM

The ratio, by weight, of monomer to strontium perchlorate is about 1 to 1.08. The mixture was heated in an oven for 24 hours at a temperature of 75 degrees C. A candle was prepared as in Example I, and the burning time was 60 seconds. The flame was between 12 and 18 inches high and was a very bright red. A white smoke was produced.

Example IV

50 ml. of methyl methacrylate monomer
50 gms. of strontium perchlorate
50 gms. of magnesium (atomized)
30 gms. of strontium carbonate
6 drops of Lupersol DDM

The ratio, by weight, of monomer to strantium perchlorate was about 1 to 1.08. The mixture was heated in an over for 24 hours at a temperature of 75 degrees C. A candle was prepared as in Example I and the burning time was 35 seconds. The flame was between 12 and 18 inches high and was a very bright red. A white smoke was produced.

Example V

50 ml. of methyl methacrylate monomer
10 gms. of strontium perchlorate
50 gms. of magnesium (atomized)
40 gms. of strontium nitrate
30 drops of Lupersol DDM

The ratio, by weight, of monomer to strontium perchlorate was about 1 to 0.21. The mixture was heated in an oven for 24 hours at a temperature of 75 degrees C. A candle was prepared as in Example I, and the burning time was 22 seconds. The flame was between 12 and 18 inches high and was a very bright red. A white smoke was produced.

Example VI

47 ml. of methyl methacrylate monomer
75 gms. of strontium perchlorate
30 gms. of magnesium (atomized)
15 gms. of aluminum (atomized)
3 drops of Lupersol DDM

The ratio, by weight, of monomer to strontium perchlorate was about 1 to 1.7. The mixture was heated in an oven for 24 hours at a temperature of 55 degrees C. A candle was prepared as in Example I and the burning time was 125 seconds. The flame was about 12 inches high and was a very bright red. A white smoke was produced.

Example VII

50 ml. of methyl methacrylate monomer
83.7 gms. of strontium perchlorate
52.3 gms. of magnesium (atomized)
3 drops Lupersol DDM

The ratio, by weight, of monomer to strontium perchlorate was about 1 to 1.79. The mixture was heated in an oven for 24 hours at a temperature of 55 degrees C. A candle was prepared as in Example I and the burning time was 110 seconds. The flame was about 12 inches high and was a very bright red. A white smoke was produced.

Example VIII

28 ml. of methyl methacrylate monomer
14 ml. of styrene monomer
90 gms. of strontium perchlorate
5 gms. of magnesium (atomized)
30 gms. of glycine
3 drops of cumene hydroperoxide

The mixture was heated in an oven for 17 hours at a temperature of 75 degrees C. A candle was prepared as in Example I, and the burning time was 155 seconds. A red flame between 6 and 8 inches high was produced and white smoke was produced. The addition of the styrene monomer greatly increases the pot life of the mixture. Glycine is particularly well suited for use as a pyrotechnic fuel as glycine does not interfere with the production of the colored flame and also as only a minimum amount of oxygen is needed to oxidize the glycine.

Example IX

56 ml. of methyl methacrylate monomer
50 gms. of strontium perchlorate
25 gms. of magnesium (atomized)
45 gms. of sulfur
10 gms. of anhydrous strontium chloride
2 drops of cumene hydroperoxide

The mixture was heated in an oven for 20 hours at 75 degrees C. A candle was made as in Example I and the burning time was 7 minutes.

As can be seen from the foregoing examples, compositions with a high magnesium content burn relatively rapid and are very hot. The addition of sulfur to the mixture increases the burning time, as demonstrated by Example IX. Sulfur is best used in a range of 0.25–0.75 part of sulfur per one part of monomer.

While the foregoing examples list methyl methacrylate as the monomer which is polymerized, strontium perchlorate mixes equally as well when mixed in solution with acrylic acid, methacrylic acid and esters of acrylic acid and methacrylic acid, such as methyl acrylate and ethyl acrylate. Also, while the examples listed above were catalyzed with either cumene hydroperoxide or Lupersol DDM there are many more commonly known catalysts that promote polymerization of acrylic monomers. Included among the known catalysts are diacyl peroxides, ketone peroxides, alkyl hydroperoxides, alkyl peresters, and alkyl acid peresters. Various effects can be obtained by the use of different catalysts and also combination of catalysts can produce effects not readily available with any single catalyst.

In preparation, the acrylic monomer is normally first mixed with the strontium perchlorate and that portion of strontium perchlorate which dissolves in the monomer causes the monomer to partially polymerize. A portion of the strontium perchlorate will dissolve in the acrylic monomer and, at room temperature, about 18 parts of anhydrous strontium perchlorate will dissolve in 100 parts of acrylic monomer. The partial polymerization of the monomer causes an increase in the viscosity of the mixture and the fuel and other ingredients are then added. The increased viscosity of the mixture prevents the fuel and other undissolved ingredients from settling and consequently, a more homogenous product is produced. Pyrotechnic candles that provide adequate candlepower when burned, and also, that have a long burning time, have been prepared by maintaining a ratio of between 1 and 3.3 parts, by weight, of strontium perchlorate to one part, by weight, of acrylic monomer.

The ratio of fuel to monomer is also critical for military applications in that too small an amount of fuel will result in low average candlepower, while too large an amount of fuel will cause very rapid burning and consequently, too short a burning time. For one red flare, for example, a military specification requires a minimum average candlepower of 20,000 and a minimum burning time of 23 seconds. In order to meet both of these requirements, the ratio of fuel to monomer should be between about 0.2 and 2.0 parts of fuel to one part of acrylic monomer.

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 is:

1. A consumable pyrotechnic composition comprising: one part, by weight, of an acrylic polymer, and between one and 3.3 parts, by weight, of strontium perchlorate.

2. A consumable pyrotechnic composition as set forth in claim 1 having uniformly dispersed therein in a finely divided form between 0.2 and 2.0 parts, by weight, of magnesium.

3. A consumable pyrotechnic composition as set forth in claim 1 having uniformly dispersed therein in a finely divided form between 0.2 and 2.0 parts, by weight, of aluminum.

4. A consumable pyrotechnic composition as set forth in claim 1 having uniformly dispersed therein in a finely divided form between 0.2 and 2.0 parts, by weight, of magnesium and between 0.25 and 0.75 part, by weight, of sulfur.

5. A consumable pyrotechnic composition as set forth in claim 1 having uniformly dispersed therein in a finely divided form between 0.2 and 2.0 parts, by weight, of magnesium and between 0.25 and 0.75 part, by weight, of glycine.

6. A consumable pyrotechnic composition comprising:

one part, by weight, of polymer consisting of two-thirds methyl methacrylate and one-third styrene,

between one and 3.3 parts, by weight, of strontium perchlorate, and

between 0.2 and 2.0 parts, by weight, of a fuel selected from the group consisting of aluminum and magnesium.

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LEON D. ROSDOL, *Primary Examiner.*

B. R. PADGETT, *Assistant Examiner.*