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(54) **IGNITING AGENT AND IGNITER CONTAINING SAME**

(57) An ignition agent contains zirconium powders, a metal boride, and an oxidizing agent.

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## Description

### TECHNICAL FIELD

5 **[0001]** The present invention relates to an ignition agent and an igniter including the same.

### BACK GROUND ART

10 **[0002]** Japanese Patent Laying-Open No. 09-227266 (PTL 1), Japanese Patent Laying-Open No. 2009-120424 (PTL 2), WO2012/008161 (PTL 3), and Japanese Patent Laying-Open No. 2016-069201 (PTL 4) disclose a composition that functions as an ignition agent in a gas generator included in an air bag or the like for an automobile.

### CITATION LIST

#### 15 PATENT LITERATURE

#### **[0003]**

20 PTL 1: Japanese Patent Laying-Open No. 09-227266  
PTL 2: Japanese Patent Laying-Open No. 2009-120424  
PTL 3: WO2012/008161  
PTL 4: Japanese Patent Laying-Open No. 2016-069201

#### 25 SUMMARY OF INVENTION

### TECHNICAL PROBLEM

30 **[0004]** Since zirconium powders are excellent in ignition performance, they are generally applicable as a combustion component of the ignition agent. Zirconium powders, however, have high electrostatic sensitivity and friction sensitivity and hence they may accidentally be ignited during manufacturing, transport, or the like. Therefore, the ignition agent containing zirconium powders has been demanded to have improved safety in handling thereof, for example, to be prevented from accidentally be ignited. In general, however, lowering in electrostatic sensitivity, friction sensitivity, or the like of the ignition agent for prevention of accidental ignition described above has been said to simultaneously lead to lower ignition performance (for example, longer time for ignition).

35 **[0005]** In view of the circumstances above, an object of the present invention is to provide an ignition agent that achieves lower electrostatic sensitivity and friction sensitivity and has good ignition performance and an igniter including the same.

#### 40 SOLUTION TO PROBLEM

**[0006]** In order to achieve the object, the present inventors conducted dedicated studies and invented the present invention. Specifically, the present inventors considered blending a metal boride in an ignition agent containing zirconium powders as a combustion component for the purpose of lowering electrostatic sensitivity and friction sensitivity thereof. Specifically, the present inventors prepared an ignition agent containing zirconium powders, a metal boride, and an oxidizing agent and evaluated performance thereof. The present inventors found that, surprisingly, the ignition agent achieved an effect to maintain good ignition performance and lower electrostatic sensitivity and friction sensitivity, and completed the present invention.

**[0007]** The present invention is characterized as below.

- 50 [1] An ignition agent according to the present invention contains zirconium powders, a metal boride, and an oxidizing agent.
- [2] Preferably, the ignition agent contains at least 19 mass % and at most 35 mass % of the zirconium powders, at least 11 mass % and at most 36 mass % of the metal boride, and at least 44 mass % and at most 62 mass % of the oxidizing agent.
- 55 [3] Preferably, the metal boride is at least one selected from the group consisting of tungsten boride, molybdenum boride, aluminum boride, titanium boride, magnesium boride, and zirconium boride.
- [4] Preferably, the oxidizing agent is a perchlorate.

[5] Preferably, the perchlorate is at least one selected from the group consisting of potassium perchlorate, sodium perchlorate, calcium perchlorate, and magnesium perchlorate.

[6] An igniter according to the present invention contains the ignition agent.

## 5 ADVANTAGEOUS EFFECTS OF INVENTION

**[0008]** According to the present invention, an ignition agent that achieves lower electrostatic sensitivity and friction sensitivity and has good ignition performance and an igniter including the same can be provided.

## 10 DESCRIPTION OF EMBODIMENTS

**[0009]** An embodiment according to the present invention (which is also denoted as the "present embodiment" below) will be described below in further detail. The expression in a form "A to B" herein represents a range from a lower limit to an upper limit (that is, A or more and B or less), and when no unit is indicated for A and a unit is indicated only for B, the unit of A is the same as the unit of B. The "ignition agent" herein means a composition that is burnt by being triggered by thermal energy such as Joule heat. Therefore, the "ignition agent" is distinguished from an agent (what is called an enhancer agent, a gas generating agent, or the like) used for generation of gas. Furthermore, the term "igniter" herein may be used to refer not only to an igniter applied to an air bag for an automobile, a pretensioner of a seat belt, and the like but also to an igniter provided in a gas generator applied to an application for performing operations in each of injection, flying, floating in the air, and the like by instantaneous generation of gas.

[Ignition Agent]

**[0010]** The ignition agent according to the present embodiment contains zirconium powders, a metal boride, and an oxidizing agent. With such a feature, the ignition agent can achieve lower electrostatic sensitivity and friction sensitivity and have good ignition performance. Accidental ignition during manufacturing, transport, or the like of the ignition agent and the igniter including the same can thus be prevented, and hence safety during manufacturing and transport of the ignition agent and the igniter can be improved. Furthermore, since the ignition agent has good ignition performance, the igniter which is quick in response by including the ignition agent can be provided. Details of each component contained in the ignition agent will be described below.

<Zirconium Powders>

**[0011]** The ignition agent according to the present embodiment contains zirconium powders. Zirconium powders function as the combustion component in the ignition agent. In other words, zirconium powders perform a function to generate heat and to generate metallic thermal particles by being oxidized in an ignition process triggered by Joule heat.

**[0012]** In the ignition agent, a content of zirconium powders can typically be from 5 to 40 mass % and preferably from 19 to 35 mass %. When the content of zirconium powders is lower than 5 mass %, good ignition performance or sufficient output (combustion) may not be obtained. When the content of zirconium powders exceeds 40 mass %, electrostatic sensitivity and friction sensitivity may be high and safety in handling thereof may not sufficiently be secured. From a point of view of maintaining good ignition performance, zirconium powders preferably have an average particle size from 0.01 to 5  $\mu\text{m}$ . The average particle size of zirconium powders can be set as appropriate in accordance with required performance of the igniter. Zirconium powders can be formed by pulverizing zirconium with a known method.

45 <Metal Boride>

**[0013]** The ignition agent according to the present embodiment contains a metal boride. The metal boride is blended for the purpose to control a degree of electrostatic sensitivity and friction sensitivity of zirconium powders. The metal boride functions also as a combustion component in the ignition agent. In other words, similarly to zirconium powders, the metal boride performs a function to generate heat and to generate metallic thermal particles by being oxidized in the ignition process triggered by Joule heat.

**[0014]** In the ignition agent, a content of the metal boride can typically be from 10 to 50 mass % and preferably from 11 to 36 mass %. When the content of the metal boride is lower than 10 mass %, electrostatic sensitivity and friction sensitivity as the ignition agent may be high and safety in handling thereof may not sufficiently be secured. When the content of the metal boride exceeds 50 mass %, good ignition performance or sufficient output (combustion) may not be obtained. In an example where the metal boride is powdery, the metal boride preferably has an average particle size from 0.01 to 5  $\mu\text{m}$ , similarly to zirconium powders. In this case, zirconium powders and the metal boride can evenly be mixed and hence safety in handling as the ignition agent can be improved. Powders of the metal boride can be formed

by pulverizing the metal boride with a known method.

**[0015]** Specifically, the metal boride is preferably at least one selected from the group consisting of tungsten boride, molybdenum boride, aluminum boride, titanium boride, magnesium boride, and zirconium boride. In the ignition agent, one of the metal borides may be used alone or at least two of them may be used as being mixed. More specifically, the metal boride is preferably at least one selected from the group consisting of tungsten boride, molybdenum boride, titanium boride, and zirconium boride.

**[0016]** The average particle size of zirconium powders and the metal boride can be measured by the Fisher method or laser diffraction.

#### <Oxidizing Agent>

**[0017]** The ignition agent according to the present embodiment contains an oxidizing agent. The oxidizing agent performs a function to oxidize zirconium powders and the metal boride which are the combustion components in the ignition agent. The oxidizing agent is preferably a perchlorate. Specifically, the perchlorate is preferably at least one selected from the group consisting of potassium perchlorate, sodium perchlorate, calcium perchlorate, and magnesium perchlorate. Among these, the perchlorate is more preferably potassium perchlorate or sodium perchlorate.

**[0018]** In the ignition agent, a content of the oxidizing agent can typically be from 20 to 70 mass % and preferably from 44 to 62 mass %. When the content of the oxidizing agent is lower than 20 mass %, an oxidation function cannot sufficiently be performed and sufficient output (combustion) as the ignition agent may not be obtained. When the content of the oxidizing agent exceeds 70 mass %, a fuel component is too little and good ignition performance may not be obtained.

#### <Optional Component>

**[0019]** The ignition agent according to the present embodiment can further contain other metal powders, another oxidizing agent, a basic substance, a binder, an agent, and/or the like as an optional component.

**[0020]** Other metal powders refer to a component that functions as the combustion component by being contained in the ignition agent together with zirconium powders. Examples of other metal powders can include tungsten powders, magnesium powders, titanium powders, molybdenum powders, magnalium powders, copper powders, and beryllium powders. In the ignition agent, one of compounds described above as other metal powders may be used alone or at least two of them may be used as being mixed. From a point of view of ease in handling during manufacturing, as other metal powders, tungsten powders or molybdenum powders are preferably used, and tungsten powders are more preferably used. A content of other metal powders is preferably 10 mass % or lower in the ignition agent.

**[0021]** Another oxidizing agent refers to a component that oxidizes the combustion component by being contained in the ignition agent together with the above-described oxidizing agent. Examples of another oxidizing agent specifically include a nitrate such as potassium nitrate, sodium nitrate, strontium nitrate, copper nitrate, magnesium nitrate, and ammonium nitrate and a chlorate such as sodium chlorate, potassium chlorate, magnesium chlorate, calcium chlorate, strontium chlorate, and ammonium chlorate. In the ignition agent, one of compounds described above as another oxidizing agent may be used alone or at least two of them may be used as being mixed. In particular, in an example where a nitrate is blended as another oxidizing agent, a mixed oxidizing agent composed of nitrate and perchlorate is preferred because it is expected to achieve both of a function to maintain good ignition performance and a function to lower friction sensitivity. A content of another oxidizing agent is preferably 30 mass % or lower in the ignition agent.

**[0022]** The ignition agent according to the present embodiment can further contain an optional basic substance. Corrosion of a metallic portion included in an igniter which will be described later can thus be suppressed. Specifically, examples of the basic substance can include metal hydroxide such as lithium hydroxide, sodium hydroxide, potassium hydroxide, rubidium hydroxide, cesium hydroxide, magnesium hydroxide, calcium hydroxide, strontium hydroxide, barium hydroxide, and aluminum hydroxide, metal oxide such as lithium oxide, sodium oxide, potassium oxide, rubidium oxide, cesium oxide, magnesium oxide, calcium oxide, strontium oxide, barium oxide, zinc oxide, thallium oxide, and cesium oxide, metal peroxide such as lithium peroxide, sodium peroxide, potassium peroxide, rubidium peroxide, cesium peroxide, magnesium peroxide, calcium peroxide, strontium peroxide, and barium peroxide, and metal carbonate such as lithium carbonate, sodium carbonate, potassium carbonate, rubidium carbonate, cesium carbonate, magnesium carbonate, calcium carbonate, strontium carbonate, and barium carbonate. One of these basic substances may be used alone or at least two of them may be used as being mixed. The optional basic substance may be water soluble or water insoluble. Metal oxide is preferred as the optional basic substance, and among others, magnesium oxide is preferred. A content of the optional basic substance is preferably 10 mass % or lower or more preferably 5 mass % or lower in the ignition agent.

**[0023]** The ignition agent according to the present embodiment can further contain a binder. Breaking strength and other mechanical properties in preparation of the ignition agent as a granular molding can thus be improved. Examples

of the binder can specifically include metal salt of carboxymethyl cellulose, polysaccharide derivatives such as hydroxymethyl cellulose, cellulose acetate, cellulose propionate, cellulose acetate butyrate, nitrocellulose, guar gum, polyvinyl alcohol, polyacrylamide, and starch, and organic binders such as stearate, fluoro-rubber, and SBS rubber. One of these binders may be used alone or at least two of them may be used as being mixed. A content of the binder is more preferably

5 5 mass % or lower in the ignition agent.

**[0024]** The binder as it is can be added to and mixed in the ignition agent according to the present embodiment, or alternatively, an appropriate solvent can also be added to the binder and then the binder can be mixed together with the solvent. The solvent can be used without being particularly restricted, so long as it is inert toward the binder, excellent in dispersibility in the binder, or satisfactorily soluble in the binder. A volatile organic solvent such as hydrocarbon, ester,

10 and ketone is preferably used as the solvent because it readily volatilizes in a drying step.

[Method of Manufacturing Ignition Agent]

**[0025]** A preferred method of manufacturing the ignition agent according to the present embodiment is as follows. For example, a step of obtaining a solution mixture is performed by initially introducing zirconium powders, the metal boride, and the oxidizing agent described above into a binder solution, further introducing above-described various optional components as necessary, and mixing these components in the solution. Furthermore, a step of obtaining a granular molding is performed by adding heptane to the solution mixture, obtaining a deposit by repeating stirring and separation, and drying the deposit. The ignition agent in a form of the granular molding can thus be manufactured. When the ignition agent in the form of the granular molding is obtained, breaking strength and other mechanical properties of the ignition agent can be improved as set forth above.

<Functions and Effects>

**[0026]** The ignition agent according to the present embodiment can be obtained through the step of obtaining the solution mixture and the step of obtaining the molding as described above. The ignition agent contains zirconium powders and the metal boride. Therefore, the ignition agent can achieve lowering in electrostatic sensitivity and friction sensitivity and good ignition performance. Thus, accidental ignition during manufacturing, transport, or the like of the ignition agent and the igniter including the same can be prevented and hence safety during manufacturing and transport of the ignition agent and the igniter can be improved. Furthermore, with the good ignition performance, by including the ignition agent,

30 an igniter quick in response can be provided.

[Igniter]

**[0027]** The igniter according to the present embodiment includes the ignition agent. With such a feature, the igniter can achieve improvement in safety during manufacturing and transport and can be quick in response. So long as the igniter according to the present embodiment includes the above-described ignition agent, it can include a known element and can be manufactured with a known method.

**[0028]** The igniter according to the present embodiment can have, for example, a structure below. Specifically, the igniter can be provided with a first cup body where the ignition agent is stored, a cover body that covers an outer periphery of the first cup body so that the first cup body is stored therein, a plug in which a plurality of electrode pins for electrical connection to the outside are fixed by an insulator, and a bridge wire connected between the plurality of electrode pins. The bridge wire, the plug, and the electrode pins are inserted in the first cup body as a plug assembly, and thereafter fixed by welding. At this time, the ignition agent stored in the first cup body and the bridge wire come in contact with

45 each other.  
**[0029]** Furthermore, the igniter can implement a gas generator by being stored in a second cup body together with a gas generating agent that generates gas. Specifically, the gas generator is composed in such a manner that the igniter is stored in the second cup body where the gas generating agent is stored, and then the first cup body and the cover body where the ignition agent is stored and the second cup body are fixed to a holder. The gas generator can be provided

50 with a known component normally used for the gas generator.  
**[0030]** When an external control unit senses a signal generated by some kind of event (for example, collision of a vehicle or the like), the control unit has a current fed to the electrode pins so that the igniter starts operations. Specifically, when the bridge wire generates Joule heat as a result of current feed to the electrode pins, the Joule heat ignites the ignition agent in contact with the bridge wire, thermal energy and a pressure generated therefrom can rupture the first cup body and flame can be emitted to the outside (second cup body). This flame then burns the gas generating agent stored in the second cup body so that the gas generator including the igniter can generate a large amount of gas.

[Safety Apparatus for Automobile]

**[0031]** A safety apparatus for an automobile according to the present embodiment includes the igniter. Examples of the safety apparatus for the automobile include a seat belt pretensioner, an air bag, and the like. With such a feature, the safety apparatus for the automobile can achieve improved safety during manufacturing and transport, and with the igniter quick in response, the safety apparatus for the automobile can quickly activate the seat belt pretensioner, the air bag, and the like. So long as the safety apparatus for the automobile according to the present embodiment includes the ignition agent and the igniter, it can include a known element and can be manufactured with a known method.

**[0032]** When the safety apparatus for the automobile is the seat belt pretensioner, a large amount of gas generated from the gas generator including the igniter described above can increase a pressure in the seat belt pretensioner to activate the seat belt pretensioner, and hence can fasten the seat belt that a passenger is using. When the safety apparatus for the automobile is the air bag, a large amount of gas generated from the gas generator described above is normally introduced through a filter from a gas discharge hole into the air bag to thereby develop the bag. When the safety apparatus for the automobile is the air bag, generation of a large amount of gas by the gas generating agent may be induced by ignition of the ignition agent and following firing and generation of gas by an enhancer agent.

[Examples]

**[0033]** Though the present invention will be described in further detail below with reference to Examples, the present invention is not limited to these Examples. Samples 11 to 14, sample 21, samples 31 to 32, and sample 41 fall under Examples and sample A, sample 1a, sample 2a, sample 3a, and sample 4a fall under comparative examples.

[Fabrication of Ignition Agent]

<Sample A>

(Step of Obtaining Solution Mixture and Step of Obtaining Molding)

**[0034]** A solution mixture was obtained by initially adding 7.2 g of commercially available zirconium powders (particle size: 1.5 to 2.0  $\mu\text{m}$ ), 8.4 g of commercially available tungsten powders (particle size: 0.7 to 1.0  $\mu\text{m}$ ), and 8.4 g of commercially available potassium perchlorate (particle size: 12 to 20  $\mu\text{m}$ ) to 250 mL of acetone solution prepared by addition of 1.0 g of fluoro-rubber as the binder to acetone and mixing with the use of a stirring blade (step of obtaining the solution mixture). Furthermore, 1640 mL of heptane was added as being split to the obtained solution mixture, a deposit was obtained by repeating stirring and separation, and the deposit was dried. Thus, 22 g of ignition agent of sample A in the form of the granular molding was obtained (step of obtaining the molding). Sample A had a composition of the ignition agent that had conventionally been used for the igniter.

<Sample 11>

(Step of Obtaining Solution Mixture and Step of Obtaining Molding)

**[0035]** A solution mixture was obtained by initially adding 4.8 g of commercially available zirconium powders (particle size: 1.5 to 2.0  $\mu\text{m}$ ), 8.6 g of commercially available tungsten boride powders as the metal boride (particle size: 5  $\mu\text{m}$ ), and 10.5 g of commercially available potassium perchlorate (particle size: 12 to 20  $\mu\text{m}$ ) to 250 mL of acetone solution prepared by addition of 1.0 g of fluoro-rubber as the binder to acetone and mixing with the use of the stirring blade (step of obtaining the solution mixture). Furthermore, 1640 mL of heptane was added as being split to the obtained solution mixture, a deposit was obtained by repeating stirring and separation, and the deposit was dried. Thus, 22 g of ignition agent of sample 11 in the form of the granular molding was obtained (step of obtaining the molding).

<Samples 12 to 14>

**[0036]** In a manner the same as in the method of fabricating sample 11 except for change of a ratio of blending (composition ratio) of zirconium powders, tungsten boride powders, and potassium perchlorate as shown in Table 1, 22 g of ignition agent of each of samples 12 to 14 was obtained.

<Sample 1a>

**[0037]** In a manner the same as in the method of fabricating sample 11 except for absence of zirconium powders and

change of a ratio of blending (composition ratio) of tungsten boride powders and potassium perchlorate as shown in Table 1, 22 g of ignition agent of sample 1a was obtained.

<Sample 21>

(Step of Obtaining Solution Mixture and Step of Obtaining Molding)

**[0038]** A solution mixture was obtained by initially adding 5.5 g of commercially available zirconium powders (particle size: 1.5 to 2.0  $\mu\text{m}$ ), 5.5 g of commercially available zirconium boride powders as the metal boride (particle size: 5 to 10  $\mu\text{m}$ ), and 12.9 g of commercially available potassium perchlorate (particle size: 12 to 20  $\mu\text{m}$ ) to 250 mL of acetone solution prepared by addition of 1.0 g of fluoro-rubber as the binder to acetone and mixing with the use of the stirring blade (step of obtaining the solution mixture). Furthermore, 1640 mL of heptane was added as being split to the obtained solution mixture, a deposit was obtained by repeating stirring and separation, and the deposit was dried. Thus, 22 g of ignition agent of sample 21 in the form of the granular molding was obtained (step of obtaining the molding).

<Sample 2a>

**[0039]** In a manner the same as in the method of fabricating sample 21 except for absence of zirconium powders and change of a ratio of blending (composition ratio) of zirconium boride powders and potassium perchlorate as shown in Table 1, 22 g of ignition agent of sample 2a was obtained.

<Sample 31>

(Step of Obtaining Solution Mixture and Step of Obtaining Molding)

**[0040]** A solution mixture was obtained by initially adding 4.5 g of commercially available zirconium powders (particle size: 1.5 to 2.0  $\mu\text{m}$ ), 4.5 g of commercially available titanium boride powders as the metal boride (particle size: 2 to 3  $\mu\text{m}$ ), and 14.8 g of commercially available potassium perchlorate (particle size: 12 to 20  $\mu\text{m}$ ) to 250 mL of acetone solution prepared by addition of 1.0 g of fluoro-rubber as the binder to acetone and mixing with the use of the stirring blade (step of obtaining the solution mixture). Furthermore, 1640 mL of heptane was added as being split to the obtained solution mixture, a deposit was obtained by repeating stirring and separation, and the deposit was dried. Thus, 22 g of ignition agent of sample 31 in the form of the granular molding was obtained (step of obtaining the molding).

<Sample 32>

**[0041]** In a manner the same as in the method of fabricating sample 31 except for change of a ratio of blending (composition ratio) of zirconium powders, titanium boride powders, and potassium perchlorate as shown in Table 1, 22 g of ignition agent of sample 32 was obtained.

<Sample 3a>

**[0042]** In a manner the same as in the method of fabricating sample 31 except for absence of zirconium powders and change of a ratio of blending (composition ratio) of titanium boride powders and potassium perchlorate as shown in Table 1, 22 g of ignition agent of sample 3a was obtained.

<Sample 41>

(Step of Obtaining Solution Mixture and Step of Obtaining Molding)

**[0043]** A solution mixture was obtained by initially adding 5.7 g of commercially available zirconium powders (particle size: 1.5 to 2.0  $\mu\text{m}$ ), 5.7 g of commercially available molybdenum boride powders as the metal boride, and 12.4 g of commercially available potassium perchlorate (particle size: 12 to 20  $\mu\text{m}$ ) to 250 mL of acetone solution prepared by addition of 1.0 g of fluoro-rubber as the binder to acetone and mixing with the use of the stirring blade (step of obtaining the solution mixture). Furthermore, 1640 mL of heptane was added as being split to the obtained solution mixture, a deposit was obtained by repeating stirring and separation, and the deposit was dried. Thus, 22 g of ignition agent of sample 41 in the form of the granular molding was obtained (step of obtaining the molding).

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<Sample 4a>

**[0044]** In a manner the same as in the method of fabricating sample 41 except for absence of zirconium powders and change of a ratio of blending (composition ratio) of molybdenum boride powders and potassium perchlorate as shown in Table 1, 22 g of ignition agent of sample 4a was obtained.

[Various Tests]

<Tank Test>

**[0045]** Sample A, samples 11 to 14, and sample 1a, sample 21 and sample 2a, samples 31 to 32 and sample 3a, and sample 41 and sample 4a were subjected to a tank test in which each sample was ignited in a prescribed safety container (tank) in accordance with a manner below so as to count time (ignition time: expressed by a unit of ms) necessary for ignition of the ignition agent of each sample.

**[0046]** Specifically, for the tank test, a test igniter, a columnar tank having a volume of 10 cc, and a jig accommodated in the tank were prepared. The test igniter was made by filling the igniter including the bridge wire with 110 mg of the ignition agent of each sample. In the tank test, each test igniter was set on a sample base of the jig and fed with a current (1.2 ampere) to generate Joule heat, and the Joule heat ignited the ignition agent of each sample. Furthermore, time from feed of the current until observation in each test igniter, of increase in pressure in the tank was obtained as the "ignition time." Table 1 shows results. In the tank test, a sample the ignition time of which was 2 ms or shorter was evaluated as the ignition agent good in ignition performance.

<Sensitivity Test (Friction Sensitivity Test and Electrostatic Sensitivity Test)>

**[0047]** Sample A, samples 11 to 14, and sample 1a, sample 21 and sample 2a, samples 31 to 32 and sample 3a, and sample 41 and sample 4a were subjected to various sensitivity tests in accordance with testing methods defined under JIS K 4810 (testing methods of explosives). Specifically, in accordance with "friction test" and "electric sensitivity test" shown in the explosive standard of the Japan Explosives Society, friction sensitivity (unit of kgf) and electrostatic sensitivity (unit of mJ) of each sample were measured and a class of each sample based on the measurement was determined. Table 1 shows results. An upward arrow in an item of electrostatic sensitivity in Table 1 means "excess".

[Table 1]

**[0048]**

Table. 1

|           | Composition Ratio (Mass %) |              |                 | Tank Test          | Sensitivity Test     |       |                           |       |
|-----------|----------------------------|--------------|-----------------|--------------------|----------------------|-------|---------------------------|-------|
|           | Zr Powders                 | Metal boride | Oxidizing Agent | Ignition Time [ms] | Friction Sensitivity |       | Electrostatic Sensitivity |       |
|           |                            |              |                 |                    | [kgf]                | Class | [mJ]                      | Class |
| Sample A  | 30                         | *35          | 35              | 0.64               | 2.4                  | 3     | 1.1                       | 2     |
| Sample 11 | 20                         | 36           | 44              | 0.76               | 24.0                 | 6     | 450                       | 4     |
| Sample 12 | 25                         | 31           | 44              | 0.73               | 16.8                 | 6     | 250                       | 4     |
| Sample 13 | 28                         | 28           | 44              | 0.74               | 12.8                 | 5     | 250                       | 4     |
| Sample 14 | 35                         | 21           | 44              | 0.76               | 10.8                 | 5     | 15                        | 3     |
| Sample 1a | 0                          | 55           | 45              | 15.49              | 28.8                 | 6     | 450↑                      | 5     |
| Sample 21 | 23                         | 23           | 54              | 1.07               | 16.8                 | 6     | 450                       | 4     |
| Sample 2a | 0                          | 40           | 60              | 15.12              | 32.4                 | 6     | 450↑                      | 5     |
| Sample 31 | 19                         | 19           | 62              | 1.26               | 21.6                 | 6     | 50                        | 4     |
| Sample 32 | 35                         | 11           | 54              | 0.88               | 14.4                 | 5     | 10                        | 3     |
| Sample 3a | 0                          | 29           | 71              | 5.24               | 32.4                 | 6     | 400                       | 4     |
| Sample 41 | 24                         | 24           | 52              | 0.84               | 16.0                 | 6     | 150                       | 4     |

(continued)

|                                                      | Composition Ratio (Mass %) |              |                 | Tank Test          | Sensitivity Test     |       |                           |       |
|------------------------------------------------------|----------------------------|--------------|-----------------|--------------------|----------------------|-------|---------------------------|-------|
|                                                      | Zr Powders                 | Metal boride | Oxidizing Agent | Ignition Time [ms] | Friction Sensitivity |       | Electrostatic Sensitivity |       |
|                                                      |                            |              |                 |                    | [kgf]                | Class | [mJ]                      | Class |
| Sample 4a                                            | 0                          | 40           | 60              | 5.81               | 21.6                 | 6     | 450↑                      | 5     |
| * Metal tungsten is blended instead of metal boride. |                            |              |                 |                    |                      |       |                           |       |

[Discussion]

**[0049]** According to Table 1, sample A, samples 11 to 14, sample 21, samples 31 to 32, and sample 41 were evaluated as being good in ignition performance because they were all shorter in ignition time than sample 1a, sample 2a, sample 3a, and sample 4a and the ignition time thereof was 2 ms or shorter. Furthermore, classes of samples 11 to 14, sample 21, samples 31 to 32, and sample 41 showed that these samples were lower in friction sensitivity and electrostatic sensitivity than sample A. It is understood from the above that samples 11 to 14, sample 21, samples 31 to 32, and sample 41 could maintain better ignition performance and be lower in electrostatic sensitivity and friction sensitivity than sample A.

**[0050]** Though the embodiment and the examples of the present invention have been described as above, combination of features in the embodiment and the examples as appropriate is also originally intended.

**[0051]** It should be understood that the embodiment and the examples disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the terms of the claims rather than the embodiment and the examples described above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

## Claims

1. An ignition agent comprising:

zirconium powders;  
a metal boride; and  
an oxidizing agent.

2. The ignition agent according to claim 1, comprising:

at least 19 mass % and at most 35 mass % of the zirconium powders;  
at least 11 mass % and at most 36 mass % of the metal boride; and  
at least 44 mass % and at most 62 mass % of the oxidizing agent.

3. The ignition agent according to claim 1 or 2, wherein the metal boride is at least one selected from the group consisting of tungsten boride, molybdenum boride, aluminum boride, titanium boride, magnesium boride, and zirconium boride.

4. The ignition agent according to any one of claims 1 to 3, wherein the oxidizing agent is a perchlorate.

5. The ignition agent according to claim 4, wherein the perchlorate is at least one selected from the group consisting of potassium perchlorate, sodium perchlorate, calcium perchlorate, and magnesium perchlorate.

6. An igniter comprising the ignition agent according to any one of claims 1 to 5.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/043348

## A. CLASSIFICATION OF SUBJECT MATTER

**C06B 29/02**(2006.01)i; **C06B 33/00**(2006.01)i; **C06B 33/06**(2006.01)i; **C06C 7/00**(2006.01)i; **F42B 5/16**(2006.01)i;  
**B60R 21/264**(2006.01)i

FI: C06C7/00; C06B29/02; C06B33/00; F42B5/16; C06B33/06; B60R21/264

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C06B29/02; C06B33/00; C06B33/06; C06C7/00; F42B5/16; B60R21/264

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996  
 Published unexamined utility model applications of Japan 1971-2023  
 Registered utility model specifications of Japan 1996-2023  
 Published registered utility model applications of Japan 1994-2023

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                             | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y         | JP 10-505573 A (DYNAMIT NOBEL AKTIENGESELLSCHAFT) 02 June 1998<br>(1998-06-02)<br>claims 13, 20, p. 5, line 25 to p. 6, line 7 | 1-6                   |
| Y         | JP 2009-120424 A (NIPPON KAYAKU CO LTD) 04 June 2009 (2009-06-04)<br>claim 1, examples                                         | 1-6                   |
| Y         | JP 6-207799 A (ASAHI CHEM IND CO LTD) 26 July 1994 (1994-07-26)<br>claim 1, examples                                           | 1-6                   |
| A         | US 5147976 A (GIAT INDUSTRIES) 15 September 1992 (1992-09-15)<br>column 3, lines 4-8                                           | 1-6                   |

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

\* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

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“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

**07 February 2023**

Date of mailing of the international search report

**21 February 2023**

Name and mailing address of the ISA/JP

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Telephone No.

INTERNATIONAL SEARCH REPORT  
Information on patent family members

International application No.

PCT/JP2022/043348

| Patent document<br>cited in search report | Publication date<br>(day/month/year) | Patent family member(s)                                                                                                                                                                       | Publication date<br>(day/month/year) |
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| JP 10-505573 A                            | 02 June 1998                         | US 2001/0030007 A1<br>claims 13, 20, paragraphs<br>[0003], [0006]<br>WO 1996/008454 A1<br>EP 1110928 A1<br>DE 19533487 A1<br>PL 319093 A<br>CZ 70797 A<br>AT 210619 T<br>KR 10-1997-0706215 A |                                      |
| JP 2009-120424 A                          | 04 June 2009                         | (Family: none)                                                                                                                                                                                |                                      |
| JP 6-207799 A                             | 26 July 1994                         | (Family: none)                                                                                                                                                                                |                                      |
| US 5147976 A                              | 15 September 1992                    | EP 468838 A1<br>DE 69105393 C<br>FR 2665254 A<br>IL 98954 A<br>GR 3015175 T                                                                                                                   |                                      |

Form PCT/ISA/210 (patent family annex) (January 2015)

**REFERENCES CITED IN THE DESCRIPTION**

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- JP 2009120424 A [0002] [0003]
- WO 2012008161 A [0002] [0003]
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