(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 074 533 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.02.2001 Bulletin 2001/06

(51) Int Cl.⁷: **C06D 5/06**, C06B 23/00

(21) Application number: **00306685.9**

(22) Date of filing: **04.08.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **06.08.1999 JP 22415599**

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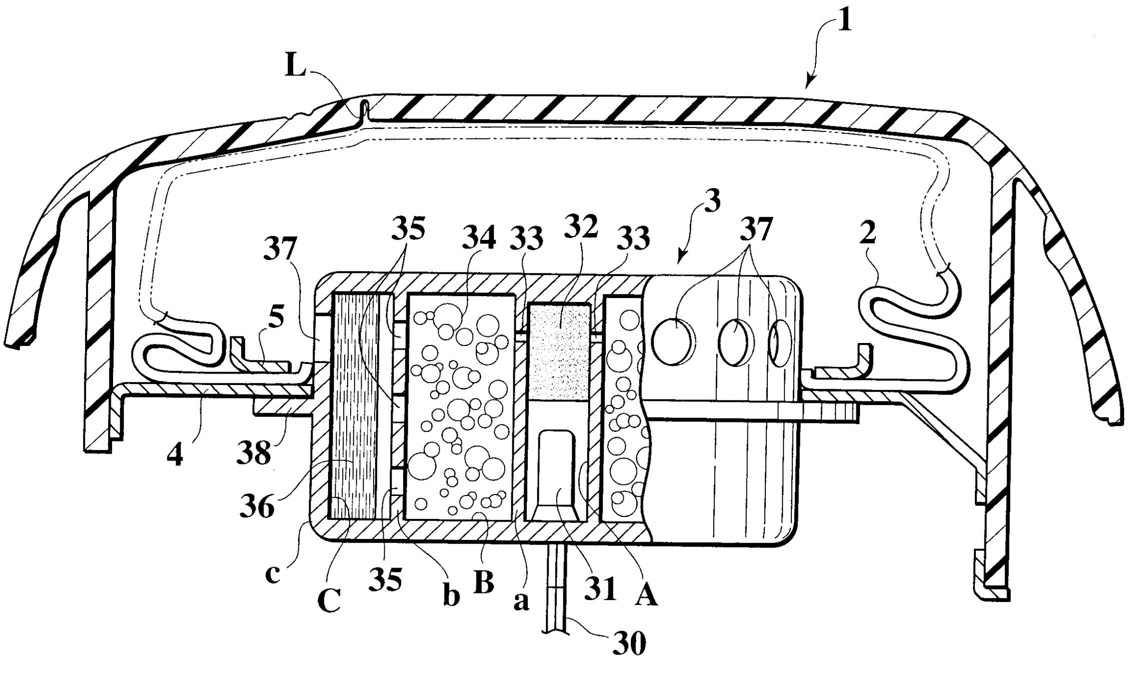
(54) Gas generating agent

(57) There is provided a gas generating agent containing ammonium nitrate, the gas generating agent comprising compounding at least one type selected from the group consisting of a simple substance of elements producing a nitrate having a heat decomposition temperature higher than the heat decomposition temperature of ammonium nitrate, an alloy of the element and a compound of the element.

FIGURE



Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a gas generating composition which is used for airbags, propellants and high pressure sources, is reduced in the amount of unacceptable gas to living bodies, is stable, has a high gas-generating efficiency and has high combustion velocity.

2. Description of the Related Art

[0002] Many solid-type gas generating agents are being used for automobile safety gas generators, e.g., airbags, propellants and high pressure sources. It is important for gas generating agents used for these purposes (1) to be reduced in the generation of unacceptable gas to living bodies, (2) to generate a large amount of gas per unit weight or unit volume, that is, to have a high gas generating efficiency, thereby making the equipment small-sized and light-weight (3) to enable gas to be supplied at a satisfactory velocity, that is, to have a large gas generating velocity and (4) to be stable against heat and impact and, accordingly, to be easily handled and to withstand long term storage. As the unacceptable gas to living bodies, nitrogen oxides, halogenated gases, carbon monoxide and concentrated carbon dioxide are exemplified in general. The solid-type gas generating agent makes use of a combustion reaction and hence usually generates these unacceptable gases in a large amount. A gas generating agents containing sodium azide generates a littel unacceptable gas, so they were used in a gas generator for airbag. However, since sodium azide itself has toxicity, it is troublesome to handle sodium azide. Sodium azide also has a low gas generating efficiency. Therefore, gas generating agents using no sodium azide have come to be used in recent years. Ammonium perchlorate is mainly used for the many types of propellants as oxidizer, however, the propellants generate a large amount of hydrogen chloride gas with combustion, giving possibility for bringing strongly acidic rain, which arouses much fear of giving rise to environmental disruption. In order to improve this drawback, studies are being made on a solid-type gas generating agent using an inorganic oxidant containing no halogen, an organic nitro compound or a nitramine compound and the like. As the inorganic oxidant for the solid-type gas generating agent, considerable attention is poured to particularly ammonium nitrate which contains no halogen, is stable, reduced in the generation of unacceptable gases and has high gas generating efficiency. In this situation, the inventor of the present invention previously invented a gas generating composition which comprises ammonium nitrate and a metal nitrate and is remarkably reduced in the generation of unacceptable gases (Patent Application No. H10-323718). However, the gas generating agent using ammonium nitrate as the oxidant has not necessarily sufficient gas generating velocity and it is hence necessary to more improve the gas generating agent in the case where a large amount of gas must be generated at a high velocity. In order to improve the velocity of gas generation, increasing the surface area and/or combustion velocity of the gas generating agent are generally effective. It is well known that the addition of an azide group member to organic materials, such as a glycidyl azide polymer which is able to burn with high combustion velocity without impregnation of any oxidizer, are effective to increase the combustion velocity of gas generating agent containing ammonium nitrate(hereafter they are called azide group-containing organic material). Ammonium nitrate contains three oxygen in its molecule, two of them will be used for oxidation of the ammonia and remaining one can only be used to oxidize other materials. In order to sufficiently increase the combustion velocity of the gas generating agent containing ammonium nitrate and organic azide compound, the amount of the azide compound should be increased. This, however, results in the generation of a large amount of unacceptable carbon monoxide. Such a gas generating agent emitting carbon monoxide to a certain extent is acceptable as the propellant for rockets but is unacceptable as a gas generating agent for airbag. So, gas generating agents obtained by combining an azide group-containing organic material or a nitrogen-containing organic material with an inorganic oxidant, e.g., strontium nitrate, potassium nitrate or potassium perchlorate, other than ammonium nitrate are studied and used at present. Comparing gas generating agents containing sodium azide with gas generating agents used at present, the former generate less unacceptable gases but the gas generating efficiency is bad, where gas generating efficiency is 40 to 60 weight % of gas to total weight of gas generating agent and 14 to 19mol/kg (the mol number of generated gas per 1kg of the gas generating agent), and the latter generate considerable amount of unacceptable gases but gas generating efficiency is good, where gas generating efficiency is 55 to 65 weight % and 20 to 25mol/kg respectively. Then, existing gas generating agent should be improved to generate a good gas composition and to have a good gas generating efficiency.

SUMMARY OF THE INVENTION

[0003] As mentioned above, a solid-type gas generating agent which is reduced in the generation of unacceptable gases, is stable, has high gas generating efficiency and is improved in gas generating rate is desired. However, these objects have not been attained sufficiently.

[0004] An object of the present invention is to provide a gas generating composition combining these properties.

[0005] The inventor of the present invention has made earnest studies and, as a result, invented a gas generating composition which can attain this object.

[0006] To achieve the object, an invention provides a gas generating agent containing ammonium nitrate, the gas generating agent comprising compounding at least one type selected from the group consisting of a simple substance of the elements producing a nitrate having a heat decomposition temperature higher than the heat decomposition temperature of ammonium nitrate, an alloy of the element and a compound of the element.

[0007] The element is, preferably, one type selected from the group consisting of magnesium, calcium and strontium.

[0008] The compound of the element is, preferably, one type selected from the group consisting of a borate, a nitride, a halide and a salt of an organic acid.

[0009] The gas generating agent, preferably, further comprises at least one of a nitrogen-containing material, a binder, an auxiliary oxidant and a metal nitride.

[0010] An invention provides an inflater of an airbag device using the gas generating agent.

[0011] An invention provides an airbag device using the gas generating agent.

[0012] According to the present invention, the gas generating agent has a higher decomposition temperature than those of conventional ammonium nitrate type gas generating agents and hence the surface temperature of the gas generating agent can be raised with the result that the combustion velocity can be increased.

[0013] According to the present invention, the gas generating agent is outstandingly increased in the gas generating velocity and is superior in the gas generating efficiency and further can restrain the generation of gas components unacceptable to living bodies.

[0014] Therefore, the gas generating agent of the present invention is useful in the fields such as airbag devices and rocket propellants in which a high gas generating efficiency and a high gas generation velocity are required.

[0015] The present disclosure relates to subject matter contained in Japanese Patent Application No.HEI11-224155, filed on August 6,1999, the disclosure of which is expressly incorporated herein by reference in its entirety.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWING

[0016] Figure shows a partially sectional view illustrating an embodiment of an airbag device containing an inflater which has a gas generating agent of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] The present invention will be explained in detail. Although no particular limitation is imposed on ammonium nitrate to be used in the present invention, for example, ammonium nitrate for industrial use, fine crystalline ammonium nitrate and phase-stabilized ammonium nitrate are preferable as ammonium nitrate.

[0018] The present invention is characterized in that at least one type selected from the group (hereinafter these compounds are generically called effective materials) consisting of simple substance from which a nitrate having a heat decomposition temperature higher than the heat decomposition temperature (210°C from Chemical Handbook) of ammonium nitrate are produced, alloys of these elements and compounds of these elements. In general, the combustion of the gas generating agent is caused as follows. Specifically, a combustion surface is heated to raise the surface temperature, causing the gas generating agent to be decomposed and to generate flammable gas and then a combustion reaction arises in the gas phase to raise the temperature of the gas thereby developing flame. At this time, it is thought that the higher the temperature of the combustion surface and the temperature of the flame are, the larger the combustion velocity becomes. The inventor of the present invention found in a calorimetric measurement using a differential scanning calorimeter (DSC) that when an element producing a nitrate having a heat decomposition temperature higher than the decomposition temperature of ammonium nitrate was compounded in a gas generating agent containing ammonium nitrate, a peak in the range of the heat decomposition temperature of ammonium nitrate vanished or became small and a peak appeared on the high temperature side. Therefore, the decomposition at the heat decomposition temperature of ammonium nitrate becomes extinct or the calorific value at that temperature remarkably decreases and decomposition arouses on the higher temperature side instead. It is understood from the shift of the peak that the temperature of the combustion surface of the gas generating agent is raised. With a rise in the temperature of the combustion surface, the combustion velocity increases. The reason of the rise in the heat decomposition temperature of the present invention is presumed to be that ammonium nitrate melts on the combustion surface where the effective materials react with ammonium nitrate to create a nitrate (or a nitrite, in the present invention, a nitrite is included in nitrates) having a higher heat decomposition temperature than ammonium nitrate. In such a case, it is generally expected that the effective material should be added to ammonium nitrate by stoichiometric amount to attain higher combustion surface temperature {in the case where the effective materials are, for example, a simple substance of magnesium, 1 mol of magnesium reacts with 2 mol of ammonium nitrate and hence ratio of the stoichiometric amount of magnesium (atomic weight: 24.3) is 24.3 g (1 mol) to 160 g (2 mol) of ammonium nitrate (molecular weight: 80)}. However, contrary to this expectation, the inventor further found that the combustion velocity was dramatically increased even in a stage in which the effective materials are added in a very small amount. If the effective materials do not react with ammonium nitrate in combustion surface as mentioned above, the combustion velocity of gas generating agent is not only increased but also the gas generating efficiency would be lowered, then good characteristics of ammonium nitrate would be lost.

[0019] On the premise that the effective materials and ammonium nitrate are used as essential components, such deterioration should be avoided that these materials react with each other and a part or all of these materials are decomposed in the temperature range in which these materials must be kept stable. Because of this reason, the compounded effective material may be commonly subjected to surface-inactivating treatment such as coating of the surface with a stable polymer, treatment for stabilizing the effective element as a compound and treatment for forming an alloy of the effective element by combining with a stable metal.

[0020] Typical examples of the effective element include lithium, sodium, potassium, silver, magnesium, calcium, strontium, cadmium, lead and bismuth. Among these elements, magnesium, calcium and strontium are desirable in view of costs, easy of availability and low metallic toxicity.

[0021] When each of these effective elements is added as a simple substance, it is preferable to add the element in a stabilized form such as a surface-inactivated powder whose surface is coated with a polymer or the like which is well-known in this technical field. When the element is added in the form of an alloy, a powder of an alloy of magnesium and aluminum (magnalium) is typified.

[0022] Also, when the effective materials are a compound, the compound may be any one of those which react with ammonium nitrate at a temperature above around the melting temperature (169.6°C in Chemical Handbook, Basic edition I, page 178) to form a nitrate or nitrite having a decomposition temperature above the decomposition temperature of ammonium nitrate when the compound is mixed with ammonium nitrate and heated, like in the case where the effective materials are in the form of simple substance of an element or an alloy of the element. This phenomenon can be easily measured by a DSC or the like. When a measurement using a DSC is made in the condition that, for example, the amount of a sample is 1 to 4 mg and the temperature is raised at a velocity of 10°C/min, heat absorption due to melting appears at about 150 to 165°C in the case only of ammonium nitrate and then a peak showing the start of decomposition appears at about 265 to 297° C (hereinafter this decomposition temperature expressed as about 280° C). On the contrary, in the case of the mixture including the effective material, the decomposition peak occurring at about 280° C becomes small or entirely vanishes and a decomposition peak newly occurs at 350 to 450° C resultantly. In the case where the effective materials are a compound, examples of the compound include salts of the effective materials and organic acids such as formic acid, oxalic acid and acetic acid and inorganic salts and inorganic compounds such as borates, nitrides, halides, thiosulfates, methaborates, chromates, bichromates and molybdates except the salt of nitrate. Among these compounds, organic salts, borates and nitrides have a high gas generating efficiency and are stable and are hence desirable.

[0023] The amount of the effective materials to be added to 1 mol (80g) of ammonium nitrate, are 0.05 to 1.1 mol and preferably 0.08 to 1 mol. In a range lower than the above defined range, only a small effect of increasing combustion velocity is obtained. On the other hand, in the case where the amount of the effective elements is greater than the above defined range, the gas generating efficiency is similar to or lower than those of conventional gas generating agents.

[0024] One or more of nitrogen-containing organic materials, binders, auxiliary oxidants and metal nitrides may be added further to the composition obtained by adding the effective materials to ammonium nitrate to control the composition of gas and the shape and strength of the gas generating agent.

[0025] As the nitrogen-containing organic material, those used usually for gas generating agents for airbags such as nitroguanidine, guanidine nitrate, tetrazole derivatives such as aminotetrazole and azodicarbonamide are exemplified.

[0026] As the binder, an inorganic binder or an organic binder may be used. As the inorganic binder, water glass is typified. When a simple substance of magnesium or ionic compounds of magnesium, calcium or strontium are used for the gas generating agent of the present invention, it reacts with ammonium nitrate in the presence of water to generate ammonia gas and to decompose ammonium nitrate. Therefore, in the case of using these simple substance, it is necessary to prevent the decomposition of ammonium nitrate by using, for instance, a method in which water glass is added to a simple substance of magnesium, or ionic compounds of magnesium, calcium or strontium to form granules, which are sufficiently dried and then added to ammonium nitrate. When a resin using a liquid polymer and a curing agent as its major components is used, general examples of the resin are urethane types comprising a prepolymer having a hydroxyl group and an isocyanate, epoxy types comprising an epoxy resin and its curing agent and polyester types comprising a prepolymer having an unsaturated bond, a radical generating agent such as a peroxide and its accelerator. A molded product of gas generating agent can be obtained such steps as adding and mixing an organic binder and then molding the mixture into a given shape, followed by curing and the like steps. Also, when a thermoplastic resin is used for the organic binder, a molded product of gas generating agent can be obtained such steps as mixing a thermoplastic resin, suchas acetylcellulose or butylcellulose, which is soluble in a solvent, a plasticizer and a solvent with the gas generating composition of the present invention and molding the mixture into a given shape, followed by drying under heat.

[0027] Because, as aforementioned, ammonium nitrate has a small number of oxygens to oxidize other compounds, the auxiliary oxidant may be added to compensate it. Given as general examples of the auxiliary oxidant are potassium nitrate, sodium nitrate and strontium nitrate. It is to be noted that potassium nitrate is preferably added to stabilize the phase change of ammonium nitrate.

[0028] The metal nitrides are bound with the oxygen of ammonium nitrate to generate heat nitrogen, besides, do not generate oxides of carbon by combustion. Hence, the gas generating agents contained the metal nitrate(s) produce clean gas and have a high gas generating efficiency. Therefore the metal nitrate is effective if it is used for a gas generating agent for airbags. The metal nitride excludes azides. Typical examples of the metal nitride are boron nitride, silicon nitride and aluminum nitride.

[0029] Other than the above components, materials, e.g., a metal powder, a molding adjuvant and a slag-forming agent, which are usually added to gas generating agents may be added according to the object.

[0030] In the gas generating agent, as aforementioned, elements such as magnesium, calcium or strontium or ionically bonded compounds have strong tendency to react with ammonium nitrate in the presence of water to generate ammonia gas and to decompose ammonium nitrate. Therefore it is necessary to decrease the presence of water remarkably. The tolerance of water is 0.2% or less, preferably 0.05% or less and more preferably 0.01% or less. These levels of water content can be obtained by sufficient drying, for example, in the case of drying under heat, by drying at about 60 to 150°C for 1 to 50 hours. Also, when the dried product is handled, it must be handled under the atmosphere having a relative humidity of 35% or less and preferably 30% or less. Moreover, since commercially available inert gases such as nitrogen and argon contain almost no water, the dried product may be handled under the atmosphere of these gases. When the water content is greater than 0.2%, ammonia is readily generated from these gas generating agents to decompose ammonium nitrate at ambient temperature. If ammonium nitrate and the gas generating agent are allowed to stand in the air having a relative humidity of 35% or more, they absorb moisture and are increased in water content resultantly.

Example 1

[0031] Ammonium nitrate produces a phase change associated with a volumetric change at 30 to 80° C. If such a phase changes should be avoided to keep the qualities and the properties of the gas generating agent, phase stabilized ammonium nitrate (called PSAN) is preferably used. Phase change of PSAN is almost vanished at temperature range of about 30 to80° C. In this example, potassium nitrate was used to prepare PSAN. PSAN was produced by adding 20 to 50% by outside percent of water to 90 % of ammonium nitrate and 10% of potassium nitrate (% means % by weight, the same as follows) and the mixture was heated to 100 to 140°C to dissolve and dried, followed by milling. Other components were chemicals which were usually used. Using these chemicals, samples having the compositions shown in Table 1 were produced. Data concerning the heat decomposition of the sample was obtained. In the measurement concerning the heat decomposition, 1.5 to 3.5 mg of the sample was filled in a container made of aluminum or stainless steel and closed by press and heated using an DSC (model 41, manufactured by Shimadzu Corporation) at a temperature rise rate of 10° C/min to measure the state of decomposition. The results are shown in Table 1. In Table 1, the decomposition starting temperature, peak temperature and heat of decomposition (the heat of decomposition determined from the area of the peak is divided by the amount of the sample and expressed in J/g units) in the range of decomposition temperature of ammonium nitrate are listed in the first decomposition peak. Those of a decomposition peak which newly appears are listed in the second decomposition peak. In this condition, as shown in Comparative Example 1, ammonium nitrate decomposes at a temperature higher than the decomposition temperature (210° C) shown in Chemical Handbook. Even if a relatively oxidizable substance is mixed as shown by the compositions of Comparative Examples 2 to 5, temperature of decomposition and heat of decomposition of the first peak are same as ammonium nitrate, and the results reveal that any combustion reactions did not take place in temperature range of first peak and only ammonium nitrate was decomposed. In the case of the gas generating agent of the present invention, first decomposition peak became smaller as shown in Example 1-2, or vanished in many cases and a new second decomposition peak appeared with the same level of heat of decomposition as first peak at higher temperature range than first peak by 70 to 130 °C.

Table 1

Number	Compounded composition					Results of DSC						Remarks
	PSAN	KN	BN	Other compounded materials		First decomposition peak			Second decomposition peak			
				Types	Compounded amount	Decomposition start temperature	Peak	Heat of decompo-sition	Decomposi-tion start temperature	Peak	Heat of decompo-sition	
	%	%	%		%	°C	°C	J/g	°C	°C	J/g	
Comparative Example 1	100.0					265	297	970				Minimum value when the test was made five times
						295	330	1530				Maximum value when the test was made five times
Comparative Example 2	66.7	13.3	20.0			289	314	1096				
Comparative Example 3	63.3	12.7	19.0	ZrB_2	5.0	278	302	913				
Comparative Example 4	63.3	12.7	19.0	Si	5.0	285	324	936				
Comparative Example 5	63.3	12.7	19.0	AIN	5.0	299	335	1392				
Example 1-1	50.0			Ac2Ca	50.0	Vanished			372	398	471	See the Note
Example 1-2	63.3	12.7	19.0	MGAL	5.0	281	314	226	368	370	1392	
Example 1-3	63.3			$MgCl_2$	37.0	Vanished			352	365	952	
Example 1-4	55.5			CaC_2O_4	44.5	Vanished			397	412	730	
Example 1-5	76.4			Ca_3N_2	23.6	Vanished			410	418	1587	
Example 1-6	60.0			CaB_6	40.0	Vanished			354	361	2589	

Note: PSAN shows the phase-stabilized ammonium nitrate described in this specification, KN shows potassium nitrate added as an auxiliary oxidant, Ac2Ca shows calcium acetate and MGAL shows magnalium containing 50% of magnesium. PSAN of Comparative Example 1 used only ammonium nitrate.

Example 2

[0032] The gas generating agent of the present invention was measured for the combustion properties. The components of each gas generating agent described in Table 2 were mixed to form a disc-type tablet having a diameter of 5 mm and a maximum thickness of about 1 mm by using a press. While, a mixture of 22% of boron and 78% of potassium nitrate was formed using a press into a tablet having a diameter of 5 mm and a weight of 150 mg per one grain as an ignition pellet. Also, as an ignition powder, a mixture of 45% of a titanium powder and 55% of potassium perchlorate was prepared. Further, a pressure container equipped with a relief valve, a gas vent pipe with a valve, an internal pressure sensor (manufactured by Kyowa Electronic Instruments Co., Ltd. Type PE-200KWS) and an ignition current terminal and having an internal volume of 15 ml and a pressure measuring instrument (oscilloscope manufactured by HEWLETT PACKARD Co., Ltd. Type 54520A) were prepared. Moreover, a detector tube type gas measuring instrument manufactured by GASTECH and a detector tube (MODEL 801) which can detect unacceptable gases, specifically, CO, Cl, NO and NH_3, which are contained in the generated gases were prepared.

[0033] As the compositions shown in Table 2, those which could generate gas in an amount as much as 25 mol/kg which was the level of the amount of the gas generated from a gas generating agent usually used at present were selected.

[0034] A nichrome wire with a diameter of about 0.4 mm was attached to the ignition current terminal of the pressure container. The aforementioned tablet of the gas generating agent was measured for its thickness. Then 0.5 to 1 g of the tablet was weighed and filled in the pressure container (the weight of the filled gas generating agent was designated as W). One ignition pellet and 100mg of ignition powder were enclosed in the pressure container, and was then sealed. Thereafter, the valve of the gas vent pipe was closed and the pressure sensor was connected to the pressure measuring instrument so that pressure could be measured. An a.c. power of about 30 V was supplied to the ignition power source to ignite the gas generating agent and the relationship between pressure and time (called pressure-time data) was measured and recorded. After the combustion was completed, the detector pipe type gas measuring instrument was attached to the gas vent pipe and the valve was opened to measure the concentration of gas by the detector tube. The results are shown in the column of toxic gas concentration in Table 2. In the pressure-time data, pressure rises gradually with time from the initial pressure (0 atm) to a maximum pressure (Pmax) and reaches an equilibrium. From this data, the combustion velocity in a test using a closed container was calculated. The principle of the calculation will be explained in detail. It is assumed that combustion of the total amount (W) of the filled gas generating agent was completed at the maximum pressure (Pmax) in the pressure-time data. A value (Pi/Pmax) obtained by dividing a pressure (Pi) at each time (ti) by the Pmax is regarded as correspondent to the ratio (Wi/W) of the amount (Wi) of the gas generating agent of which combustion is completed to the total amount (W). Namely, the formula: Pi/Pmax=Wi/W, is established. Here, Pi, Pmax and W have been measured from experimental values and hence Wi can be calculated. The sum of Wi and Wr is W, where Wr is the amounts of the gas generating agent of which combustion is uncompleted at each time (ti). Therefore, since Wr = W - Wi, Wr can be calculated. On the premise that the diameter and thickness of the initial gas generating agent is D_0 and T_0 respectively, each combustion distance of the agent of which combustion is completed until each time (ti) is hi, the density of the gas generating agent is d and the number of grains of the gas generating agent is n, following equations are obtained.

$$W = (\pi/4) \times n \times d \times D_0^{2} \times T_0$$

$$Wr = (\pi/4) \times n \times d \times (D_0 - 2 \times hi)^2 \times (T_0 - 2 \times hi)$$

$$= W - Wi$$

From the above relationship;

$$Wi/W = 1 - (Wr/W)$$

$$= 1- (D_0 - 2 \times hi)^2 \times (T_0 - 2 \times hi)/(D_0^{2} \times T_0)$$

[0035] Since the parameters other than hi are known, hi can be calculated. Thus, each combustion distance (hi) at each time(ti) can also be calculated. For example, the combustion velocity at a pressure of 150 atm (about 15 MPa) is given by the following formula, if the time (ti) and the combustion distance (hi) at 148 atm and the time (t_{i+1}) and the combustion distance (h_{i+1}) at 152 atom are determined.

$$(h_{i+1} - hi)/(t_{i+1} - ti)$$

[0036] The combustion velocity at 150 atom was calculated in this manner. The results are described in the column of combustion velocity in Table 2. As a consequence, the gas generating agent of the present invention has a higher gas generating efficiency than conventional gas generating agents, is remarkably reduced in the amount of unacceptable gases (for example NO is contained in an amount of the order of 1000 ppm in combustion gas from current gas generating agents for airbags) and is increased in the combustion velocity 2 to 10 times of those of the comparative examples. In Table 2, ND means "not detected" and NM means "not measured".

Example 3

[0037] An embodiment in which the gas generating agent of the present invention is used for an inflater of an airbag device will be explained with reference to FIG. 1. The gas generating agent of the present invention is, as shown by the symbol 34 in FIG. 1, used in an inflater 3 of an airbag device for a vehicle driver which is disposed in the center of a steering wheel of automobiles.

[0038] In the FIGURE, the airbag device is constituted of a cover 1, an airbag 2 which is folded and stored in the cover 1 and the inflater 3 supplying gas to the airbag 2. The airbag 2 is made of a chemical fiber which has good physical properties, preferably Nylon 66.

[0039] The cover 1 and the inflater 3 are attached via a base plate 4.

[0040] The inside surface of the cover 1 is attached to one end of the base plate 4 by using a hook and a rivet (not shown) and the upper surface of a flange-mounted section 38 of the inflater 3 is attached to the other end by a stud bolt and nut (not shown) which are secured to a retainer 5. The end section of the airbag 2 is disposed above the flange-mounted section 38, pressed from above by the retainer 5 and secured by the above stud bolt and nut.

[0041] The cover 1 is made of a soft resin and cleft from the tear line L when the airbag is expanded and the airbag 2 is developed to catch a passenger thereby protecting the passenger.

[0042] The inflater 3 is enclosed by an external wall $\underline{c}$ which is designed to withstand against pressure generated when combustion of the gas generating agent is completed. The inflater 3 is partitioned into an ignition chamber A disposed most inside, a combustion chamber B disposed between chamber A and a filter chamber C and the filter chamber C is disposed most outside and stores a filter 36. The ignition chamber A is provided with an igniter 31 which generates heat and ignites when a predetermined current flows through a lead wire 30 and with the ignition pellets 32 which is ignited by the igniter 31 to generate a combustion products comprising high temperature gas and/or high temperature particles. A dividing wall $\underline{a}$ disposed between the ignition chamber A and the combustion chamber B is provided with a first gas outlet 33. When a combustion product is generated in the ignition chamber A, the combustion product passes through the first gas outlet 33 and flows into the combustion chamber B. The combustion chamber B is provided with the gas generating agent 34. The combustion product from the chamber A ignite the gas generating agent 34 to generate the combustion gas. The filter 36 is disposed on the outer periphery of the combustion chamber B or downstream of gas flow. A dividing wall $\underline{b}$ and a second outlet 35 are disposed between the combustion chamber B and the filter 36. The dividing wall $\underline{b}$ is designed to have a mesh-form. In addition, the gas generating agent 34 maybe filled up to the inside peripheral surface of the filter 36 without forming the dividing wall $\underline{b}$. The gas generated in the combustion chamber B flows into the filter chamber C and not only removes a slag from the gas but also cools the gas. The external wall $\underline{c}$ disposed outside of the filter 36 has a plurality of third outlet 37. The gas passing through the filter 36 passes through the third gas outlet 37 and spouted into the airbag 2.

[0043] It should be understood that the foregoing invention relates to only a preferred embodiment of the invention, and that it is intended to cover all changes and modifications of the example of the invention herein chosen for the purposes of the disclosure, which do not constitute departures from the sprit and scope of the invention.

[0044] Materials such as calcium nitrate, magnesium nitrate and strontium nitrate in the specification are so sensitive to water that they react with moisture in the air. Then they decompose and generate a great deal of heat and unacceptable ammonia. We assume no responsibility and shall nave no liability of any kind, consequential or otherwise from above disclosure.

Table 2

Number	Compounded composition								Combustion velocity	Number of mols of gas	Concentration of toxic gas			
	PSAN	KN	BN	Effective materials 1		Effective materials 2		Total			CO	CL	NO	NH3
	%	%	%	Type	%	Type	%	%	mm/s	mol/Kg	PPM	PPM	PPM	PPM
Example 2-1	80.0	0.0	0.0	MGAL	20.0			100.0	5.83	28.0	NM	NM	290	ND
Example 2-2	85.0	0.0	0.0	MGAL	15.0			100.0	3.25	31.3	NM	NM	120	ND
Example 2-3	80.0	0.0	5.0	MGAL	15.0			100.0	4.40	28.7	NM	NM	90	ND
Example 2-4	85.0	0.0	5.0	MGAL	10.0			100.0	2.15	32.0	NM	NM	40	ND
Example 2-5	63.3	12.7	19.0	MGAL	5.0			100.0	2.69	26.1	NM	NM	20	ND
Example 2-6	80.0	3.0	11.0	$MgCl_2$	6.0			100.0	2.45	32.3	NM	10	10	ND
Example 2-7	80.0	0.0	10.0	CaB_6	10.0			100.0	2.90	29.4	NM	NM	0	ND
Example 2-8	80.0	0.0	10.0	Ca_3N_2	10.0			100.0	3.60	31.5	NM	NM	60	ND
Example 2-9	80.0	0.0	0.0	Ca_3N_2	20.0			100.0	7.01	32.2	NM	NM	50	ND
Example 2-10	80.0	0.0	10.0	CaC_2O_4	10.0			100.0	4.20	32.2	ND	NM	20	ND
Example 2-11	80.0	0.0		CaC_2O_4	10.0	CaB_6	10.0	100.0	3.86	28.9	ND	NM	50	ND
Example 2-12	80.0	0.0		CaC_2O_4	5.0	CaB_6	15.0	100.0	6.28	30.9	ND	NM	20	ND
Example 2-13	80.0	0.0	10.0	Sr_3N_2	10.0			100.0	2.66	31.7	NM	NM	10	ND
Example 2-14	80.0	0.0	10.0	SrC_2O_4	10.0			100.0	3.52	32.4	ND	NM	20	ND
Comparative Example 6	60.0	20.0	20.0					100.0	0.82	26.1	NM	NM	10	ND
Comparative Example 7	63.3	12.7	19.0	ZrB_2	5.0			100.0	0.86	26.1	NM	NM	10	ND
Comparative Example 8	63.3	12.7	19.0	Si	5.0			100.0	0.72	26.1	NM	NM	10	ND

Note: In the column of type of effective materials, abbreviations are the same as in Table 1.

Claims

1. A gas generating agent containing ammonium nitrate, the gas generating agent comprising compounding at least one type selected from the group consisting of a simple substance of elements producing a nitrate having a heat decomposition temperature higher than the heat decomposition temperature of ammonium nitrate, an alloy of the element and a compound of the element.

2. A gas generating agent according to Claim 1, wherein the element is one type selected from the group consisting of magnesium, calcium and strontium.

3. A gas generating agent according to Claim 1, wherein the compound of the element is one type selected from the group consisting of a borate, a nitride, a halide and a salt of an organic acid.

4. A gas generating agent according to Claim 2, wherein the compound of the element is one type selected from the group consisting of a borate, a nitride, a halide and a salt of an organic acid.

5. A gas generating agent according to any one of Claims 1 to 4, the gas generating agent further comprising at least one of a nitrogen-containing organic material, a binder, an auxiliary oxidant and a metal nitride.

6. An inflater of an airbag device using the gas generating agent as claimed in any one of Claims 1 to 4.

7. An inflater of an airbag device using the gas generating agent as claimed in Claim 5.

8. An airbag device using the gas generating agent as claimed in any one of Claims 1 to 4.

9. An airbag device using the gas generating agent as claimed in Claim 5.

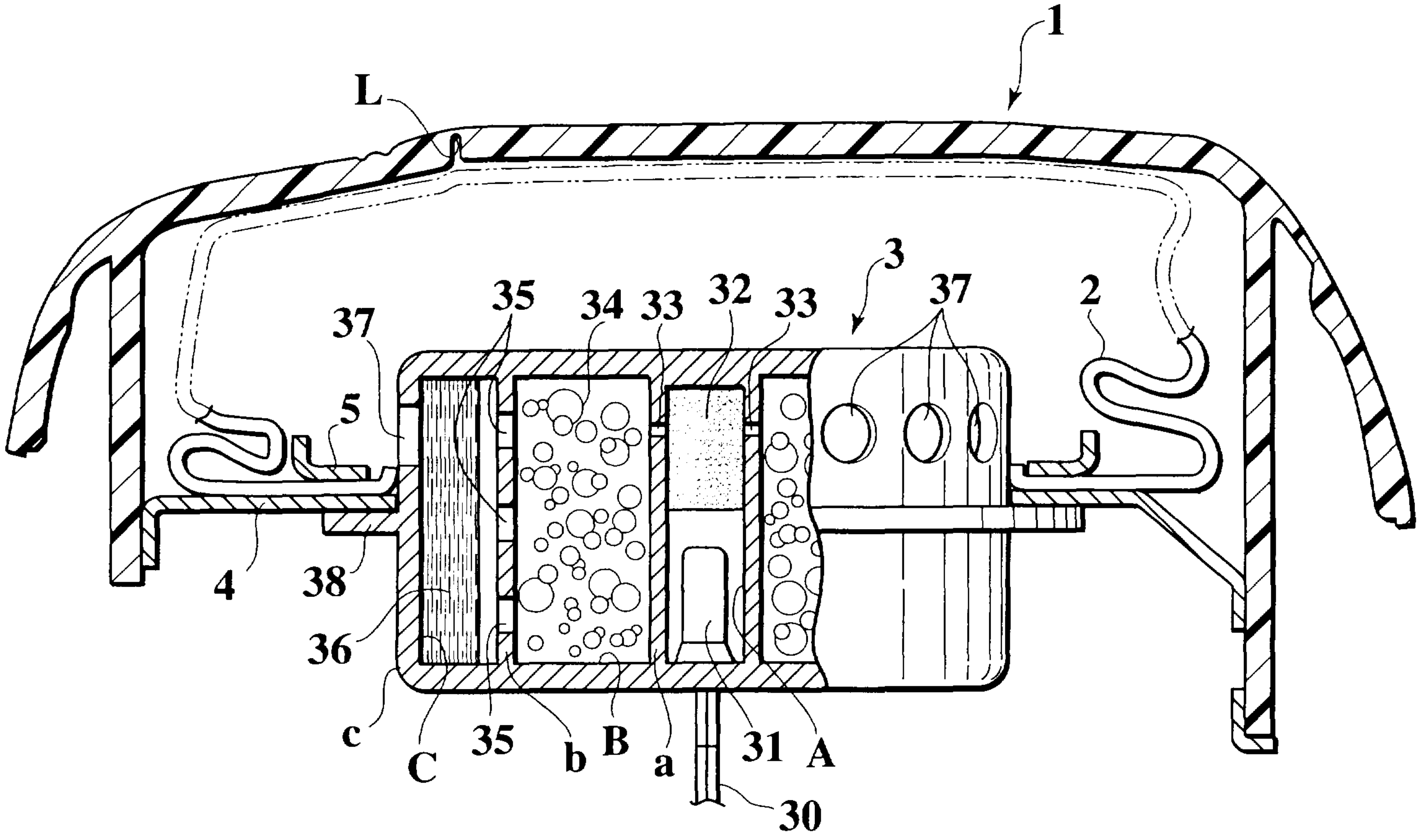
10. A gas generating agent comprising:

ammonium nitrate; and
at least one effective material selected from simple substances, alloys, or compounds of elements producing a nitrate having a heat decomposition temperature higher than the heat decomposition temperature of ammonium nitrate.

11. A gas generating agent as claimed in claim 10, wherein the ammonium nitrate is in fine crystalline or phase-stabilised form.

12. A gas generating agent as claimed in claim 10 or 11, wherein the effective material has been subjected to a surface-inactivating treatment.

FIGURE



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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 6685

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	2 November 2000	Schut, R

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