A method for inflating a gas bag of a safety arrangement in vehicles provides a gas generator which contains a pyrotechnic propellant comprising an organic fuel and ammonium perchlorate as an oxidizing agent. The pyrotechnic propellant, after its activation, releases a gas which has an amount of hydrochloric acid. A coating is arranged on the inner surface of the gas bag, on which the hydrochloric acid is neutralized or absorbed.
METHOD FOR INFLATING A GAS BAG AND GAS BAG MODULE FOR USE IN THIS METHOD

TECHNICAL FIELD

[0001] The invention relates to a method for inflating a gas bag of a safety arrangement in vehicles and also a gas bag module for use in this method.

BACKGROUND OF THE INVENTION

[0002] Safety arrangements for vehicles usually contain a gas bag module which comprises an inflatable gas bag and a gas generator connected to the gas bag. The gas generator usually contains a pyrotechnic propellant which is activated as a result of a vehicle accident and within a very short space of time releases a gas or gas mixture for inflating the gas bag.

[0003] In the past, in particular mixtures of sodium azide and inorganic nitrates were used as pyrotechnic propellant. Owing to the high toxicity of these mixtures, recently, however, propellants based on organic fuels and inorganic oxidizing agents are being used. These azide-free propellants are distinguished by high combustion temperatures which favour the occurrence of liquid or gaseous by-products. Therefore, large quantities of so-called slag-forming constituents or cooling agents must be added to these azide-free propellants, which, however, reduce the gas yield of the propellant.

[0004] In the motor vehicle industry, on the other hand, requirements exist for a miniaturizing of all systems, including the safety arrangements. Therefore, the use of pyrotechnic propellants with gas yields of over 95 percent would be advantageous, so that the overall size and the weight of the gas generators can be further reduced.

[0005] A possibility for the production of pyrotechnic propellants with a high gas yield would consist in the use of ammonium perchlorate as oxidizing agent. With the burning of propellants containing ammonium perchlorate, however, hydrochloric acid is produced as a by-product, which is not desirable, owing to its toxicity and corrosivity. Therefore, ammonium perchlorate has been used as oxidizing agent in pyrotechnic propellants for vehicle occupant restraint systems hitherto only in small proportions and/or in a mixture with suitable compounds, such as, for example, alkali metal nitrates, for the neutralization of the hydrochloric acid occurring during burning in the propellant. These mixtures, however, likewise have an insufficient gas yield, owing to the additives which are then necessary.

[0006] From the U.S. Pat. No. 4,556,236 it is known to arrange a closed container in the gas bag, which is filled with scented or aromatic substances, in order to mask unpleasant smells of the gas used for inflating the gas bag. The container may, for example, be a plastic bag which is able to be torn open. Neither the type of substances nor the composition of the gases released from the gas generator is, however, described in further detail. The described arrangement of an additional container in the gas bag leads, moreover, to increased structural space requirements. Also, a complete distribution of the substances arranged in the container during the short unfolding phase of the gas bag is not guaranteed.

[0007] The WO-A 96/13405 relates to a method for reducing the toxicity of gases which are released in the combustion reaction of an azide-free fuel and which contain nitrous oxides and carbon monoxide. For conversion of the nitrous oxides and of the carbon monoxide, provision is made to coat the inner wall of the gas bag with a double coating of an alkaline compound and of an oxidation catalyst. The coating therefore promotes only the adjustment of the balance of the components present in the gas mixture which, however, will be dependent on further external parameters such as pressure and temperature and will only occur to a very incomplete extent owing to the short reaction time which is available.

[0008] Therefore, the need continues to exist for gas bag modules with gas generators which owing to the use of pyrotechnic propellants with a high gas yield are able to be produced so as to be very small and also light and at a favourable cost, by dispensing with cumbersome and expensive filter materials.

SUMMARY OF THE INVENTION

[0009] To solve this problem, in accordance with the invention a method is proposed for inflating a gas bag of a safety arrangement in vehicles comprising the steps of: providing a gas generator, and a gas bag connected to the gas generator, the gas generator containing a pyrotechnic propellant consisting essentially of an organic fuel and ammonium perchlorate as oxidizing agent and also, in relation to the weight of said organic fuel and ammonium perchlorate, between about 0 and 10 percent by weight of conventional additives, and the gas bag having a coating arranged on an inner surface of the gas bag; activating the pyrotechnic propellant, thereby releasing a gas which contains a proportion of hydrochloric acid; supplying the gas to the gas bag and neutralizing or absorbing the hydrochloric acid on the coating in the gas bag.

[0010] The use of ammonium perchlorate as prevailing or even sole oxidizing agent makes possible the provision of gas-generating mixtures which are practically totally converted into gas during combustion. Hereby, a maximum efficiency of the propellant is achieved. Ammonium perchlorate is, furthermore, compatible with almost all organic fuels. The gas generators, owing to the use of pyrotechnic propellants with a high gas yield of over 95 percent, can be operated with a smaller quantity of propellant than conventional gas generators. Gas yield is to be understood here as the mass of the generated gas in relation to the mass of the propellant which is used. The gas generators can therefore be produced so as to be smaller and, by dispensing with cumbersome and expensive filter materials, also lighter and more favourably priced. The hydrochloric acid occurring from the reaction of the ammonium perchlorate with the fuel is reliably neutralized inside the gas bag. Therefore, no toxic or corrosive gas arrives into the interior of the vehicle. Furthermore, through the evolution of heat of the neutralization reaction, the service life of the gas bag is also increased.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0011] In accordance with the invention, the coating has a constituent of chemical substances which react directly with the hydrochloric acid and convert the latter into harmless solid reaction products. Thereby, the gaseous hydrochloric
acid occurring in the combustion reaction is reliably held back in the gas bag. The chemical substances can be selected for example from the group consisting of the oxides, peroxides, hydroxides, carbonates, hydrogen carbonates and oxalates of alkali metals, alkaline earth metals and transition metals and also mixtures thereof. These substances are easily available and favourably priced. Furthermore, for example, organic amines or polymeric compounds with basic functional groups are also able to be used. Polymeric compounds of the group of polyamines and ion exchanger resins are suitable to a particularly preferable extent. All these substances are also able to be used in a mixture with each other.

Moreover, surface-active substances can also be used for the coating, on which the gaseous hydrochloric acid can be absorbed. Particularly suitable as surface-active substances are synthetic silicic acid, aluminum oxide and aluminum hydroxide, titanium oxide, activated carbon, soot, nano-powder and mixtures thereof, which have a high specific surface. The surface-active substances can be used both in a mixture with each other and also in a mixture with the previously mentioned chemical substances for the neutralization of the hydrochloric acid.

An alternative method in accordance with the invention provides for a gas generator to be made available which contains a pyrotechnic propellant with an organic fuel and ammonium perchlorate as oxidizing agent, the pyrotechnic propellant releasing a gas after its activation which contains a proportion of hydrochloric acid, and with the activation of the pyrotechnic propellant releasing surface-active substances with an absorptive power for hydrochloric acid or chemical substances and being supplied to the gas bag preferably in very finely distributed form, which react in the gas bag directly with the hydrochloric acid and convert the latter into harmless solid reaction products. As surface-active substances or chemical substances, the previously mentioned substances, also in a mixture with each other, can be used. In this way, the efficiency of the propellant is maintained in the sense of a high gas yield, whereas the danger of damage to the gas bag fabric by hot particles is almost ruled out.

The invention further provides a gas bag module for use in the method described above, which comprises a gas bag and a gas generator connected to the gas bag. The gas generator contains a pyrotechnic propellant which consists essentially of an organic fuel and ammonium perchlorate as an oxidizing agent, and up to 10 percent by weight of conventional additives for pyrotechnic propellants, in relation to the weight of fuel and ammonium perchlorate. Preferably the propellant consists exclusively of the organic fuel and ammonium perchlorate, whereby the provision of pyrotechnic propellants with up to 100 percent gas yield is possible. The gas bag has a coating for neutralizing or absorption of hydrochloric acid released from the pyrotechnic propellant.

Compounds of the general total formula $\text{C}_x\text{H}_y\text{N}_z\text{O}_w$ wherein $x \geq 1$, $y \geq 1$ and $z \geq 0$ and $w \geq 0$ are suitable as organic fuels. The usability of organic compounds is almost universal. The only ones which are ruled out are compounds with characteristics which are not desirable for the purpose of application in motor vehicles, such as, for example, high toxicity, carcinogenic characteristics, mutagenic characteristics or other unacceptable characteristics related to the environment, such as for example a high danger for waters or soil. Furthermore, compounds are not desirable which have a chemical or thermal stability which is too low, or a storage stability which is too low in test trials at 100 degrees C. over 400 hours. In addition, compounds are to be ruled out which do not permit a safe processing in the production of the pyrotechnic propellants, such as sensitive high explosive substances or mixtures.

Particularly suitable also are fuels based on polymeric substances such as, for example, epoxy resins which offer particular advantages in the production of extruded propellants. Moreover, organic fuels which already have as high an oxygen content per molecule as possible are preferred, because hereby the required proportion of ammonium perchlorate and hence the proportion of hydrochloric acid in which it is neutralized can be reduced.

Tetrazoles, triazoles or guanidine compounds rich in nitrogen, and also mixtures thereof, are used for example as organic fuels. Examples of these compounds are 5-aminotetrazole, 1H-tetrazole, bistetrazole, azotetrazole, triazolone, nitrotetrazolone, guanidine carbonate, guanidine nitrate, guanidine perchlorate, aminoguanidine nitrate, dianinoguanidine nitrate, triaminoguanidine nitrate, nitroguanidine and also salts, derivatives or mixtures thereof.

The organic fuel can, in addition, be selected from the group consisting of nitrogenous heterocyclic organic acids and mixtures thereof. Examples of these nitrogenous heterocyclic organic acids are cyanuric acid, isocyanuric acid, cyamelide, urazole, urucle, uramine, urazine, alloxane, alloxanic acid, alloxantin, xanthine, allantoin, barbituric acid, orotic acid, dilituric acid, triazolone, viologurc acid, succinimide, dialuric acid, isodialuric acid, hydantoin, pseudohydantoin, imidazolone, pyrazolone, parabanic acid, furazane, ammeline, creatinine, malic acid hydrazide, uric acid, pseudouridic acid, guanazine, guanazolene, melanine, and their salts and derivatives or mixtures thereof.

In addition, a nitrogen-free organic acid can be used as organic fuel. Fumaric acid, maleic acid, malonic acid, tartaric acid, tartronic acid, citric acid, ascorbic acid, the salts or derivatives thereof, or mixtures of the nitrogen-free organic acids, are preferred in this connection.

Finally, as organic fuel a polymer compound can be used which can be selected for example from the group consisting of the polylkyl compounds, polyalkylene compounds, polyamides, polyiymides, polyesters, polyethers, polycarbonates, polyacrylic compounds and polyglycols and also their derivatives and copolymers containing —OH, —CN, —COOH, —NH$_2$, —NO$_2$ or —ONO$_2$ groups.

The conventional additives are selected in particular from the group of combustion moderators, cooling agents and ignition aids. Also, the addition of a small proportion of further oxidizing agents can be advantageous to improve the burning temperature or the burning speed. Examples of these conventional additives are, in particular, alkali metal nitrates and alkaline earth metal nitrates, perchlorates and peroxides, transition metal oxides such as copper oxide or iron oxide, basic metal nitrates such as basic copper nitrate or soot, graphite, silicon dioxide, aluminium oxide or molybdenum sulphide. Finally, the conventional additives
may include processing aids, such as for example trickling aids, compacting aids and/or lubricants.

[0022] The conventional additives are used in a proportion of up to 10 percent by weight, in relation to the total weight of fuel and ammonium perchlorate. Higher proportions lead to an undesirably low gas yield of the propellant. If the additives themselves are not at least partially converted into a gaseous reaction product, their proportion preferably amounts to a maximum 5 percent by weight, particularly preferably a maximum 3 percent by weight.

[0023] In burning tests with propellants containing ammonium perchlorate, it was surprisingly found that even with the use of an excess of ammonium perchlorate and hence high proportions of hydrochloric acid in the propellant gas, it was not possible to detect the gaseous hydrochloric acid by measurement techniques. A possible explanation for this lies in the high solubility of gaseous hydrochloric acid in water, so that it can be assumed that immediately after the burning of the propellant, hydrochloric acid aerosols are formed from the generated gaseous hydrochloric acid and water vapour which likewise occurs, which condense during cooling on the inner wall of the gas bag and are thus removed from the gas phase. Through the arrangement of a coating neutralizing or absorbing the hydrochloric acid, this condensation process can be further substantially accelerated. The amount of the coating is preferably selected so that the total hydrochloric acid occurring in the combustion reaction from the propellant is neutralized. The emission of harmful gaseous hydrochloric acid into the interior of the vehicle is therefore reliably prevented.

[0024] On the basis of these observations, it is also to be assumed that the neutralization of the hydrochloric acid in the gas bag takes place particularly effectively when the fuel which is used has sufficient proportions of hydrogen residues which are oxidized to water in the combustion reaction with ammonium perchlorate. Advantageously, the proportion of hydrogen residues in the fuel is to be at least so high that for every molecule of hydrochloric which is formed, at least one molecule of water is produced.

[0025] The method according to the invention and the gas bag module according to the invention make possible the provision of smaller and lighter gas generators which can be operated with pyrotechnic propellants using ammonium perchlorate as oxidizing agent. At the same time, however, with these gas generators it is ensured that no harmful gaseous hydrochloric acid arrives from the gas bag module into the interior of the vehicle.

1. A method for inflating a gas bag of a safety arrangement in vehicles comprising the step of: providing a gas generator and a gas bag connected to the gas generator, the gas generator containing a pyrotechnic propellant consisting essentially of one or more of an organic fuel and ammonium perchlorate and, in relation to the weight of the fuel and ammonium perchlorate, between 0 and 10 percent by weight of conventional additives, and the gas bag having a coating arranged on an inner surface of the gas bag; activating the pyrotechnic propellant, thereby releasing a gas which contains an amount of hydrochloric acid, supplying the gas to the gas bag, and neutralizing or absorbing the hydrochloric acid on the coating in the gas bag.

2. The method according to claim 1, characterized in that the coating comprises an amount of chemical substances which are reacted immediately with the hydrochloric acid to convert the hydrochloric acid into harmless solid reaction products.

3. The method according to claim 2, characterized in that the chemical substances are selected from the group consisting of the oxides, peroxides, hydroxides, carbonates, hydrogen carbonates and oxalates of alkali metals, alkaline earth metals and transition metals and mixtures thereof.

4. The method according to claim 2, characterized in that the chemical substances are selected from the group consisting of organic amines and polymeric compounds with basic functional groups.

5. The method according to claim 4, characterized in that the polymeric compounds are selected from the group of polyamines and ion exchanger resins.

6. The method according to any of claims 1, characterized in that the coating comprises surface-active substances capable of absorbing hydrochloric acid.

7. The method according to claim 6, characterized in that the surface-active substances are selected from the group consisting of synthetic silicic acid, aluminium oxide and aluminium hydroxide, titanium dioxide, activated carbon, soot, nanopowder and mixtures thereof.

8. A method for inflating a gas bag of a safety arrangement in vehicles comprising the steps of: providing a gas generator and a gas bag connected to said gas generator, the gas generator containing a pyrotechnic propellant consisting essentially of one or more of an organic fuel and ammonium perchlorate and, in relation to the weight of fuel and ammonium perchlorate, between about 0 and 10 percent by weight of conventional additives; activating the pyrotechnic propellant, thereby releasing a gas, which contains an amount of hydrochloric acid and, concurrently with the activation of the pyrotechnic propellant, releasing and supplying chemical substances from said gas generator to the gas bag, which react in the gas bag immediately with the hydrochloric acid and convert the hydrochloric acid into harmless solid reaction products.

9. A gas bag module for use in a safety arrangement in vehicles, comprising a gas bag and a gas generator connected to the gas bag, the gas generator containing a pyrotechnic propellant which consists essentially of one or more of an organic fuel and ammonium perchlorate and, in relation to the weight of the fuel and the ammonium perchlorate, between about 0 and 10 percent by weight of conventional additives, and the gas bag having a coating adapted for the neutralization or absorption of hydrochloric acid released from the pyrotechnic propellant.

10. The gas bag module according to claim 9, characterized in that the pyrotechnic propellant consists of the organic fuel and ammonium perchlorate.

11. The gas bag module according to claim 10, characterized in that the pyrotechnic propellant has a gas yield, related to mass, of over 95 percent.

12. The gas bag module according to any of claims 9, characterized in that the coating comprises an effective amount of chemical substances which are adapted for reacting immediately with the hydrochloric acid.

13. The gas bag module according to claim 12, characterized in that the chemical substances are selected from the group consisting of the oxides, peroxides, hydroxides, car-
bonates, hydrogen carbonates and oxalates of alkali metals, alkaline earth metals and transition metals and mixtures thereof.

14. The gas bag module according to claim 12, characterized in that the chemical substances are selected from the group consisting of organic amines and polymeric compounds with basic functional groups.

15. The gas bag module according to claim 14, characterized in that the polymeric compounds are selected from the group of polyamines and ion exchanger resins.

16. The gas bag module according to claim 9, characterized in that the coating comprises surface-active substances with a capability of absorbing hydrochloric acid.

17. The gas bag module according to claim 16, characterized in that the surface-active substances are selected from the group consisting of synthetic silicie acid, aluminium oxide and aluminium hydroxide, titanium dioxide, activated carbon, soot, nanopowder and mixtures thereof.

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