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54 **A process for the production of an acetylene base stable fuel gas, the products obtained by this process and the use of the produced acetylene base fuel gas.**

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73 Proprietor: **NATIONAL RESEARCH AND DEVELOPMENT, INC.**  
**4841 North Scottsdale Road**  
**Scottsdale Arizona (US)**

72 Inventor: **Hayes, Edward O.**  
**8102 East Willetta Street**  
**Mesa Arizona 85207 (US)**

74 Representative: **Grundy, Derek George Ritchie et al**  
**CARPMAELS & RANSFORD 43, Bloomsbury Square**  
**London WC1A 2RA (GB)**

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## Description

### Field of the invention

This invention relates to an improved, economical, efficient process for generating an acetylene base fuel gas of enhanced stability and safety and of high BTU content that will burn, for example, to heat boilers or power internal combustion engines, with a minimum amount of deleterious emissions. The invention also relates to a process for producing an acetylene base fuel gas with no undesirable by-products, such as calcium hydroxide, which create disposal problems. Instead, the by-product of this process is an excellent top cylinder lubricant (TCL) when the gas is used as a fuel for internal combustion engines.

### Background of the invention

The making of acetylene gas from the reaction of water with calcium carbide has long been known. There are in fact two processes, one known as the "wet" process and the other as the "dry", both being disclosed in the U.S. patent to Osborg, No. 2,785,052, granted March 12, 1957. In both processes the industry has long been plagued with the disposal of the unwanted residue, namely, calcium hydroxide or lime. In the wet process, the residue is a wet slurry of hydrated lime. In the dry process, the residue is in the form of a substantially dry powder, some of which becomes entrained with the acetylene gas and desirably is filtered out before the gas is burned, as disclosed in U.S. Patent to Foster No. 3,498,767. In any event, disposal of the unwanted residue of lime is a considerable problem in the industry. Furthermore, both processes are exothermic and develop considerable heat so that cooling means must be provided to maintain the acetylene at a safe temperature.

Moreover, the acetylene produced by both processes is thermodynamically unstable even at room temperatures and even in the absence of air, as is well known in the art. The thermal decomposition of acetylene can proceed so rapidly that explosions and detonations may result. Consequently, governmental safety regulations prescribe detailed procedures for handling, storage, and shipment of acetylene.

An old Belgian Patent No. 132,113, dated November 26, 1897, suggest that acetylene can be produced without an unwanted wet lime by-product by reacting an acid, e.g., hydrochloric acid, with calcium carbide to produce acetylene and calcium chloride. The patent states that the main success of such reaction is the slow release of the gas. That patent discloses that the acid is sprayed onto a bed of carbide. According to applicant's experience, however, the reaction of calcium carbide with hydrochloric acid is quite violent and extremely difficult to regulate, particularly when the carbide is added to the liquid acid. Furthermore, and contrary to the teachings of the

Belgian patent, it has been found that the addition of acid to calcium carbide results in a frothy and unworkable mass which inhibits the release of the gas. It also has been suggested, e.g., U.S. Patent to Mackusick No. 588,230, August 17, 1897, that the reaction of calcium carbide with water to produce acetylene can be slowed and made more uniform by the addition of glycerine or other substances, e.g., dextrine, sugar, glucose, etc. to the water. The above-mentioned Osborg patent also suggests the addition of an inert "carrier" liquid, e.g., an alcohol, an amine, or a glycol, to the water to have better control and reduce the exothermic heat of the reaction. The addition of a glycol to the water for anti-freeze purposes also is suggested in "Acetylene, Its Properties, Manufacture and Uses" by Miller, Vol. I, 1965, Academic Press, pages 291—292. Unfortunately, each of the processes of Mackusick, Osborg and the publication "Acetylene, etc." remain plagued by the formation of unwanted lime as a by-product.

With the advent of shortages of common liquid fuels for internal combustion engines such as gasoline, diesel fuel and the like, increased attention has been directed recently toward operation of internal combustion engines on gaseous fuels which are not in such short supply and/or which may be produced by refining techniques which are less complicated and expensive than those employed in the production of conventional liquid fuels. For example, much effort has been directed recently to the use of normally gaseous fuels, such as propane, hydrogen, natural gas, ammonia, and the like. Prior workers, however, have concluded that acetylene, which can be produced by relatively simple technology in low-pressure generators by reacting calcium carbide with water, cannot be employed practically to power internal combustion engines because of the particulate reaction product, i.e., calcium hydroxide, which, if not filtered out, is carried into the engine from the generator and also because the high combustion temperatures of acetylene create problems in obtaining adequate cylinder lubrication. In fact, an internal combustion engine fueled by acetylene produced by conventional processes will soon "burn out".

Thus, despite the fact that acetylene is a very clean burning fuel, having a relatively high thermal energy content, little attention has been directed to its use as an automotive fuel or for use in firing steam boilers, etc.

Economic studies reveal that plentiful sources of raw materials, e.g., coal and limestone, are currently available in the United States for the production of solid calcium carbide, these sources being independent of the world petroleum supply. Further studies have now indicated that improved methods are available for producing solid calcium carbide readily and inexpensively from these sources. In the substantial quantities of the raw materials

which would be required for use in producing acetylene gas for powering internal combustion engines for automobiles and other vehicles (see, for example, U.S. Patent No. 3,664,134), firing boilers, heating residences and office buildings, etc., it appears that improved processes for producing calcium carbide, together with the process for producing an improved fuel gas therefrom as disclosed herein, can compete most effectively with other conventional processes for producing fuels from conventional fuel materials such as petroleum, coal, oil shale, etc.

One disadvantage attendant on the use of calcium carbide as a fuel source is its great tendency to hydrolyze readily in air. To overcome this problem calcium carbide presently is stored and shipped in sealed drums, a considerable expense when large amounts are involved. The U.S. Patent to Lancaster, No. 683,562, dated October 1, 1901, suggests coating the carbide with various water impervious substances, such as mixtures of petroleum, glucose and carbonate of lime, a mixture of paraffin wax, cocoa butter and sugar. Before use, however, the coated carbide must be broken up to provide access of water thereto. That patent also suggests saturating the carbide with creosote, plain or diluted, to protect it from air or water. If the creosote is undiluted, however, it must be neutralized with potassium hydrate or other suitable alkali before the carbide is used to produce acetylene by contact with water. If the creosote is diluted, the protection from air or water is weakened greatly, although the carbide may be used without neutralization but with the acetylene-generating reaction with water slowed considerably. These prior processes for avoiding premature hydrolysis of carbide suffer from the problem that pretreatment of the carbide prior to generation of acetylene is required or else the generation is slowed to an impractical rate.

Accordingly, it is an object of this invention to provide an improved, economical, efficient process for the production of an acetylene base, more stable, safer fuel gas of high BTU content by the reaction of calcium carbide with an inexpensive liquid reagent, which gas can be directly utilized as an efficient gaseous fuel for internal combustion engines and in other applications, such as production of electricity, etc., with a minimum of deleterious emissions.

It is another object of this invention to provide such a process which does not produce an undesirable by-product residue which could create problems of waste disposal and use of the gas in internal combustion engines.

It is another object of this invention to provide such a process which will produce an acetylene base fuel gas which contains by-product compounds that form an advantageous top cylinder lubricant for an internal combustion engine.

A further object of the present invention is to

provide a novel top cylinder lubricant composition which forms a part of an acetylene base fuel gas for an internal combustion engine.

These and other objects of the present invention will become more apparent from the following detailed description.

#### Summary of the invention

In accordance with the present invention, there is provided an improved process for producing an acetylene base relatively safe fuel gas of enhanced stability which comprises reacting a metal carbide (preferably an alkaline earth metal carbide) with an aqueous liquid activator reagent comprising water, an alkylene glycol or an alcohol or a mixture thereof as a water-soluble reaction-rate-controlling substance and a strong inorganic acid, such as hydrochloric, sulfuric, phosphoric, carbonic or nitric acid or a mixture thereof. Attendant to this process is the production of an acetylene base fuel gas which contains a top cylinder lubricant composition. In the preferred embodiment of the present invention, calcium carbide is reacted with a liquid aqueous activator reagent which comprises water, a lower alkylene glycol (preferably ethylene glycol) and a strong inorganic acid (preferably hydrochloric acid).

In order to provide a more stable reactant which has a longer storage life, the invention further provides a means for stabilizing calcium carbide so as to render it impermeable to air and moisture by coating particles of calcium carbide with an air and moisture impermeable film, preferably of nitrocellulose and a polyester resin, which is attacked and dissolved when brought into contact with the aqueous liquid activator reagent of the present invention.

The acetylene base fuel produced according to the present invention is a gaseous reaction product which further includes vaporized or entrained by-product compounds which are a most effective top cylinder lubricant for an internal combustion engine.

The advantages attendant to the processes and fuel of the present invention are many. Thus utilizing the activator reagent of the present invention, one obtains an unexpected amount of acetylene base fuel produced over what has been obtained in the art heretofore. Thus utilizing the reaction of the present invention, one is able to obtain up to 8 cubic feet of fuel gas for each pound of calcium carbide (0.5 m<sup>3</sup>/kg) reacted which contrasts to the approximately 4.5 cubic feet 0.28 m<sup>3</sup>/kg) of acetylene obtained by conventional water and carbide reaction processes. Furthermore, the acetylene base fuel gas produced according to the present invention exhibits enhanced BTU output over that of natural gas, i.e., up to about 1447 per cubic foot (54.5 × 10<sup>6</sup> J/m<sup>3</sup>) for the gas of the present invention as contrasted to about 1448 BTU 54.6 × 10<sup>6</sup> J/m<sup>3</sup>) for pure acetylene and about 879 BTU 33.1 × 10<sup>6</sup> J/m<sup>3</sup>) for natural gas.

A significant advantage which resides in the

process herein disclosed is the elimination of lime waste disposal problems attendant on the conventional reaction of calcium carbide with water. Utilizing the aqueous liquid activator the formation of lime waste by-product is eliminated and provides for a reagent medium which can be used for extended periods of time without replenishment.

Furthermore, the acetylene base fuel gas which is produced in accordance with the present invention is characterized by having enhanced storage capabilities. Previously, acetylene produced according to conventional methods from carbide needs be made in reactor and stored in the presence of a flammable solvent filler, such as acetone, at a pressure not exceeding 15 psi (1.03 bar). The acetylene base fuel gas obtained according to the present invention may be stored at relatively high pressures (e.g., up to 250 psi—17.24 bar) without the presence of a solvent filler such as acetone, thereby permitting high storage capabilities. Storage in the presence of the activator actually enhances the ability of the gas to be stored at high pressures. Furthermore, the acetylene base fuel gas obtained in accordance with the present invention is relatively stable and will not decompose readily at room temperatures, even in the presence of air. As a result, in generating the acetylene base fuel gas according to the present invention one need not purge the reaction vessel of air prior to reaction.

A further advantage of the process of this invention is that the reaction is far less exothermic than that of calcium carbide with water alone. In fact, the amount of heat generated in the reaction is so low as to require no cooling of the generator. The reaction of calcium carbide in water results in a heat of reaction of 215°F (101°C) whereas the heat of reaction utilizing the reagent of the present invention is 140°F (60°C).

#### Detailed description of the invention

The present invention provides a process for producing an acetylene base fuel gas which comprises the steps of reacting a metal carbide, preferably an alkaline earth metal carbide, with an aqueous liquid activator reagent composed of water, an alkylene glycol or an alcohol or a mixture thereof as a water-soluble reaction-rate-controlling substance (preferably a water-soluble lower alkylene glycol), and an inorganic strong acid.

The preferred carbide is calcium carbide. It will be appreciated by those skilled in the art, however, that other carbides can be employed, such as aluminum carbide and iron carbide, at a resulting increase in cost.

Suitable inorganic strong acids include hydrochloric, sulfuric phosphoric, carbonic and nitric acids, or mixtures thereof, with hydrochloric acid being preferred for ready availability, low cost and lack of unpleasant side reactions.

The reaction-rate-controlling substance not only retards the rate of reaction but also contributes to the stability of the gas produced. In addition the substance serves to lower the reaction temperature. Suitable reaction-rate-controlling substances are water-soluble alkylene glycols and water-soluble alcohols, or mixtures thereof, with the glycols being preferred because of their unflammability.

Preferably, the liquid activator reagent is prepared by mixing the water and substance components and then introducing the acid, such as hydrochloric acid, into the water-substance mixture. The carbide then is added, at a controlled rate, to the reagent, rather than vice-versa, for better control of the release of gas.

The reaction of the liquid activator reagent with calcium carbide can be carried out at atmospheric pressure or at moderate pressures, say of the order of 18 psi (1.24 bar), and produces a fuel gas containing upwards of 89%, or even more, acetylene, which fuel gas also contains vaporized and/or entrained compounds which form a most effective top cylinder lubricant for an internal combustion engine.

Acceptable ranges of weight proportions of the components of the liquid activator reagent are about

30	water	30 to 60% (preferably 35 to 40%)
35	ethylene glycol	25 to 45% (preferably 25 to 30%)
40	hydrochloric acid-concentrated (e.g. 23° Baume)	10 to 45% (preferably 30 to 40%)

A decrease in the proportion of the glycol in the reagent increases the reaction rate and vice-versa. Similarly, an increase in the proportion of the acid increases the reaction rate and vice-versa. In the preferred proportion ranges of the reagent, the reaction proceeds uniformly and relatively slowly without foaming (which occurs in the conventional "wet" method of producing acetylene and which inhibits release of the gas) and without the formation of a by-product hydroxide precipitate. If the glycol proportion is decreased below the minimum level, the gas tends to become unstable and hazardous like acetylene generated by the reaction of calcium carbide with water only. Consequently, the glycol proportion should be large enough to insure stability of the gas with the attendant advantage of being subjectable to higher pressures without danger, and so that the reaction can be better controlled, i.e. uniformly regulated. Further, a decrease in the glycol proportion results in a decrease in the TCL by-product, so it would seem that the glycol enters

into the reaction. If the acid proportion is decreased below the minimum level, an undesirable hydroxide by-product precipitate is formed which presents a disposal problem.

In the preferred ranges, however, and in even the acceptable ranges, the gas is produced at a uniform rate leaving a greasy oily by-product residue, having some particulate matter, floating on the liquid reagent. This residue can be removed easily by circulating the reagent through an appropriate filtering system. When heated and filtered, the by-product residue forms an excellent lubricant for moving parts. The reagent can be used for long periods of time without replenishment. Thus, the main reactant is the carbide.

Some of the by-product residue is entrained and/or vaporized with the gas and will burn therewith. When the gas is used as a fuel for an internal combustion engine, the by-product residue mixed therewith forms an excellent top cylinder lubricant (TCL) which is drawn into each cylinder on the fuel intake stroke of the piston and burned with the gas on the power stroke. Thus, the TCL is constantly replenished in the cylinder. The efficacy of the by-product residue is TCL has been demonstrated by use of the gas as fuel for a Tecumseh air-cooled, one cylinder, 3 HP internal combustion engine. The engine has been so fueled and operated for at least 1000 hours, sometimes at over rated RPMs, with no signs of cylinder, piston, piston ring, or valve wear. Examination of the cylinder shows no build-up or hardening of the TCL by-product and that its lubricating qualities are most efficacious under the cylinder's high temperature operating conditions. The gaseous fuel also has been used to power several automobile engines with similar beneficial lubricating results. This is in marked contrast to an engine which when fueled by substantially pure acetylene will "burn out" after a few hours of operation without addition of lubricant to the cylinder.

Moreover, the gaseous fuel of this invention mixes with air more readily than gasoline and when burned produces far less undesirable and deleterious emissions than the burning of gasoline and air. In fact, a 1974 Dodge® van with no catalytic converter was equipped to be selectively powered with gasoline or the gaseous fuel of this invention and the emissions were measured by a State of Arizona vehicle inspection station. The maximum emissions allowed at that inspection were 400 parts per million (PPM) of hydrocarbon (HC) and 5.5% carbon monoxide (CO). When powered with gasoline the inspection emission results were 410 HC (PPM) and 14.5% CO and the vehicle failed to pass inspection. When powered with the gaseous fuel of this invention, however, the inspection emission results were 60 HC (PPM) and 0.14% CO and the vehicle passed the inspection by a large margin.

More recent comparative tests with a 1974

Chevrolet® 350 V-8 engine not equipped with a post combustion emission control device e.g., a catalytic converter, when idling at 850 RPM produced emissions when selectively powered with three types of fuels as follows:

	Gasoline	Propane	Gaseous Fuel of this Invention
	Hydrocarbons	Hydrocarbons	Hydrocarbons
	(PPM)	(PPM)	(PPM)
	250	100	0.10
	Carbon Monoxide	Carbon Monoxide	Carbon Monoxide
	(%)	(%)	(%)
	1.5	1.0	0.05

#### Preparation of liquid activator reagent

As distinguished from prior art production of acetylene by hydrolysis of calcium carbide, the process of the present invention employs a special 3-component liquid activator reagent which reacts with the calcium carbide to achieve the results described. The liquid activator reagent comprises water, a water-soluble alkylene glycol or alcohol and a strong inorganic acid, preferably hydrochloric acid.

The term "water-soluble alkylene glycol", as used herein, is intended to include all glycols having substantial solubility in water. For example, in the practice of my invention, one can employ ethylene glycol, propylene glycol, 1,3-propanediol, *meso*-2,3-butanediol, 1,4-butanediol, glycerol (1,2,3-propanetriol), *cis*-1,3-cyclopentanediol or 2-methyl-1,2-pentanediol.

Preferably, from the standpoint of each of handling, cost and availability, ethylene glycol is employed in the formation of the liquid activator reagent.

The term "water-soluble alcohols", as used herein, is intended to include all alcohols (primary, secondary and tertiary) having substantial solubility in water and generally includes those having from 1 to 8 carbon atoms. Suitable alcohols include methanol, ethanol, isopropanol, butanol and mixtures thereof. Alcohols are not preferred, however, because in general they make the activator reagent flammable.

According to the presently preferred practice of the present invention, the glycol component is merely mixed with the water component of the activator, for example, in a vessel containing an appropriate agitator, and the acid is then added to the water-glycol mixture. The relative proportions of water, glycol and acid in the liquid activator reagent will have an effect on the rate of the reaction, the final compo-

sition of the fuel gas, and the by-product residue or top cylinder lubricant which are produced when the liquid activator reagent is reacted with calcium carbide.

The water present in the aqueous liquid activator reagent may be added separately or obtained from the acid employed. The amount of water present must be sufficient to provide the necessary reaction with the carbide material. The presence of the alkylene glycol serves to control the rate of reaction and hence rate of formation of the acetylene base fuel gas, as well as the amount of the TCL by-product, and should be sufficient to provide a smooth even generation of safer more stable gas and an adequate amount of TCL when the gas is used to fuel an internal combustion engine.

The presence of the strong inorganic acid should be sufficient to eliminate the formation of a lime (calcium hydroxide) by-product.

In commercial usage, the liquid reagent of this invention can be prepared and shipped as a two-component concentrate composition, namely, a mixture of a water-soluble alkylene glycol or alcohol and a strong inorganic acid in proper proportions, the mixture to be added to the appropriate amount of water at the reaction site. This procedure avoids the cost of shipping the water component of the reagent. A suitable concentrate contains from about 35 to 82% by weight of the glycol or alcohol component, e.g., ethylene glycol, and from about 18 to 65% by weight of the acid. Such a concentrate when mixed with water forming about 30 to 60% by weight of the mixture results in the desired activator reagent.

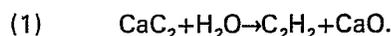
In order to enhance the capability of calcium carbide used in the reaction of the present invention to be stored without deterioration, it is preferred to stabilize the calcium carbide particles so as to render the same impermeable to air and moisture. This is accomplished by coating the particles of calcium carbide with a film, impervious to air and moisture but dissoluble by the reagent, preferably composed of nitrocellulose and a polyester resin. In carrying out such a process, one merely contacts the particles of calcium carbide with a slurry of nitrocellulose and polyester resin in a suitable organic solvent such as acetone, isopropyl alcohol or mixtures thereof. After contacting the calcium carbide particles with the slurry, the excess slurry is drained and the particles may be dried, for example in a convection dryer, to yield particles having a film thereon impermeable to air and moisture. While the resulting coated particles are impermeable to air and moisture, upon contact with the aqueous liquid activator reagent of the present invention, the coating is broken down or dissolved and reaction occurs to generate the desired acetylene base fuel gas.

An example of a suitable slurry for coating the carbide granules is:

	Nitrocellulose-RS	10%
5	Santolite (aromatic sulfonamide-formaldehyde alkyd resin)	10%
	Dibutylphthalate	2%
10	Ethyl alcohol	5%
	Ethyl acetate	34%
	Toluene	39%
15		<hr/> 100%

#### Fuel gas and TCL formation

The fuel gas and associated by-product residue which is an excellent top cylinder lubricant (TCL), are formed by reacting the liquid activator reagent, described above, with granular calcium carbide. The calcium carbide is metered, as required, into a closed reactor or generator containing the liquid activator reagent to produce the requisite quantity of the gaseous acetylene base fuel. The generator desirably is operated at approximately 15—20 psi (1.03—1.26 bar), preferably about 18 psi (1.24 bar). The reaction goes to completion when the quantity of water in the liquid activator reagent in the generator is approximately stoichiometrically equivalent to the calcium carbide metered and charged to the generator, according to the theoretical equation



Any calcium hydroxide produced by the reaction is converted to a soluble salt, e.g.,  $\text{CaCl}_2$ , by reaction with the acid and goes into solution in the reagent. Experiments have shown that the reagent is not consumed appreciably during prolonged practice of the process and needs to be replaced or replenished only after prolonged use. It is desirable, however, to periodically or continuously filter out the by-product floating residue.

#### Production of TCL

The mechanism of the formation of and the exact identity of TCL in the gaseous acetylene base fuel is not yet fully understood, but it would appear that the ethylene glycol enters into the reaction. All that is presently known is that at least a portion of the calcium moiety of the solid calcium carbide fuel appears to react with the glycol and acid components of the liquid activator reagent to form a compound which is at least transiently volatile, or is entrained, and some of which passes from the generator along with the gaseous fuel. The mixture of the compound and gaseous fuel then can be fed into the carburetor of an internal combustion engine or to a fuel burner for a

boiler or the like. Experimental observation has determined that the TCL compound is present in a substantially constant amount in the upper portion of the combustion cylinders of an engine when fueled by the gas of this invention.

As indicated, the step of production of the liquid activator reagent consists of two sub-steps involving the mixing of water and the alkylene glycol component. The mixed water-glycol composition is then further mixed by addition of the acid thereto followed by additional mixing. In the event the acid and alkylene glycol components are mixed first and this reagent concentrate shipped for a reduction in shipping costs, this concentrate is added to the appropriate amount of water at the reaction site. The resulting liquid activator reagent is then charged into a gas production generator into which solid calcium carbide granules are metered. The reaction product from the generator, comprising the acetylene base gas-TCL composition mixture is then metered to its point of use, i.e., a burner for a boiler or the like or the carburetion system of an internal combustion engine, where it is burned to provide power.

It has been found that with a liquid reagent having proportions within the preferred ranges, about 8 cu. ft. of gaseous fuel is produced from each pound (0.5 m<sup>3</sup>/kg) of calcium carbide, with the gaseous fuel having a molecular weight of about 26.3, specific gravity of .908 and BTU content of up to at least 1447 per cubic foot (54.5×10<sup>6</sup> J/m<sup>3</sup>) (dry basis) at 14.695 psia (1 bar) and 62°F (16.5°C). This compares most favorably with the production of acetylene gas from the reaction of calcium carbide with water alone of only about 4.5 cubic feet of gas per pound (0.28 m<sup>3</sup>/kg) of carbide with the acetylene having a BTU content of about 1448 per cubic foot (54.6×10<sup>6</sup> J/m<sup>3</sup>)

The following examples are offered to more fully illustrate the invention but are not to be construed as limiting the scope thereof:

#### Example one

Into an eight gallon pressure steel reactor was placed 4 gallons (0.014 m<sup>3</sup>) of activator having the following composition:

Water	4 parts (36.4% by weight)
Ethylene glycol	3 parts (27.2% by weight)
Hydrochloric acid (conc.)	4 parts 36.4% by weight)

Thereafter, one pound (0.454 kg) of calcium carbide granules (0.25 inc (0.64 cm mesh) was metered in quarter pound (0.113 kg) increments into the activator solution at a rate so as to maintain the reactor pressure at 15 psia (1.03 bar). After purging, a sample of the gas

produced was collected, analyzed and found to have the following composition:

	Component	Mol percent
5	Acetylene	89.62
	Hydrogen	1.55
10	Carbon dioxide	1.68
	Oxygen	2.54
	Methane	0.96
15	Propane	0.54
	Iso-butane	0.54
20	Carbon monoxide	0.48
	Hydrogen sulfide	2.59

The gaseous product had a molecular weight of 26.3, specific gravity of 0.909 (calculated) and a heating value (BTU-calculated) of 1358 per cubic foot (51.2×10<sup>6</sup> J/m<sup>3</sup>) (dry basis) at 14.696 psia (1 bar) at 60°F (16.5°C).

The presence of the sulfide undoubtedly was due to impurities in the calcium carbide.

#### Example two

The procedure of Example one was repeated using an activator having the following composition (parts by weight):

35	Water	4 parts (44.4%)
	Ethylene glycol	3 parts (33.3%)
40	Hydrochloric acid (conc.)	2 parts (22.3%)

The resulting gas was collected in a collection tube at 16 psia (1.10 bar) and upon analysis, found to have the following composition:

	Component	Mol percent
50	Acetylene	94.05
	Hydrogen	0.60
	Carbon dioxide	1.07
55	Nitrogen	3.24
	Oxygen	0.54
	Methane	0.10
	Carbon monoxide	0.40

The gaseous product has a specific gravity of 0.894 (calculated) and a heating value (BTU-

calculated) of 1424 per cubic foot ( $53.7 \times 10^6$  J/m<sup>3</sup>) (dry basis) at 14.696 psia (1 bar) at 60°F. (16.5°C).

#### Example three

In the same manner as Example One, fuel gas was generated by reacting calcium carbide with an activator having the following composition (parts by weight):

Water	4 parts (50%)
Ethylene glycol	3 parts (37.5%)
Hydrochloric acid (conc.)	1 part (12.5%)

The resulting gas was collected in a collection tube at 25 psia (1.72 bar) and upon analysis found to have the following composition:

Component	Mol percent
Acetylene	94.09
Hydrogen	0.10
Carbon dioxide	0.86
Nitrogen	4.00
Oxygen	0.50
Methane	0.02
Carbon monoxide	0.43

The gaseous product has a specific gravity of 0.892 (calculated) and a heating value (BTU-calculated) of 1437 per cubic foot ( $54.1 \times 10^6$  J/m<sup>3</sup>) (dry basis) at 14.696 psia (1 bar) at 60°F. (16.5°C).

The gas produced as described can fuel the internal combustion engine of an automobile without detectable atmospheric pollution, with about one-half the amount of acetylene base gas being required to power the engine as compared to natural gas.

It thus will be seen that the objects and advantages of this invention have been fully and effectively achieved. It will be realized, however, that the foregoing specific embodiments have been disclosed only for the purpose of illustrating the principles of this invention and are susceptible of modification without departing from such principles.

#### Claims

1. A process for the production of an acetylene base stable fuel gas which comprises reacting a metal carbide with an aqueous liquid activator reagent comprising water, an alkylene glycol or an alcohol or a mixture thereof as a

water-soluble reaction-rate-controlling substance, and an inorganic strong acid.

2. A process according to claim 1 wherein the carbide is an alkaline earth metal carbide.

3. A process according to claim 2 wherein the carbide is calcium carbide.

4. A process according to any one of claims 1 to 3 wherein the alkylene glycol is ethylene glycol, propylene glycol, 1,3-propanediol, *meso*-2,3-butanediol, 1,4-butanediol, glycerol, *cis*-1,2-cyclopentanediol or 2-methyl-1,3-pentanediol.

5. A process according to claim 4 wherein the glycol is ethylene glycol.

6. A process according to any one of claims 1 to 5 wherein the inorganic strong acid is hydrochloric, sulfuric, phosphoric, carbonic or, nitric acid or a mixture thereof.

7. A process according to claim 6 wherein the inorganic strong acid is hydrochloric acid.

8. A process according to any one of claims 1 to 7 wherein the proportion of acid in the reagent is sufficient to substantially prevent the formation of calcium hydroxide by-product residue.

9. A process according to any one of claims 1 to 8 in which the liquid activator reagent is prepared by mixing the water and substance components and introducing the acid into the water-substance mixture.

10. A process according to claims 5 and 7 in which the weight proportions of the components of the reagent are

Water	30 to 60%
Ethylene glycol	25 to 45%
Hydrochloric acid (conc.)	10 to 45%

11. A process according to claims 5 and 7 in which the weight proportions of the components of the reagent are

Water	35 to 40%
Ethylene glycol	25 to 30%
Hydrochloric acid (conc.)	30 to 40%

12. A process according to any one of claims 1 to 11 wherein the carbide which is employed is characterized by the presence of an air and moisture impermeable coating which is insoluble by said reagent.

13. A process according to claim 12 wherein the coating is formed from nitrocellulose and a polyester resin.

14. A process according to claim 13 wherein the coating is formed by:

(a) contacting particles of the metal carbide

- with a slurry of nitrocellulose and a polyester resin in an organic solvent;
- (b) removing excess slurry from the particles; and
- (c) drying the particles to evaporate the solvent whereby the particles are impermeable to air and moisture but are reactive with the aqueous liquid activator.

15. A top cylinder lubricant composition comprising a reaction by-product produced by reacting a metal carbide with a liquid activator reagent comprising water, an alkylene glycol or an alcohol or a mixture thereof as a water-soluble reaction-rate-controlling substance, and a strong inorganic acid.

16. A composition according to claim 15 in which the alkylene glycol is ethylene glycol.

17. A composition according to claim 15 or claim 16 in which the acid is hydrochloric, sulfuric, phosphoric, carbonic or nitric acid or a mixture thereof.

18. A composition according to claim 17 in which the acid is concentrated hydrochloric acid.

19. A composition according to any one of claims 15 to 18 in which the carbide is calcium carbide.

20. A lubricant composition according to claims 16 and 18 in which the weight percentages of the components of the liquid activator reagent are

Water	30 to 60%
Ethylene glycol	25 to 45%
Hydrochloric acid (conc.)	10 to 45%

21. A lubricant composition according to claims 16 and 18 in which the weight percentages of the components of the liquid activator reagent are

Water	35 to 40%
Ethylene glycol	25 to 30%
Hydrochloric acid (conc.)	30 to 40%

22. A method of operating an internal combustion engine comprising introducing as the fuel component of the fuel-air charge for said engine, the acetylene base fuel gas produced by the process of any one of claims 1 to 14.

#### Patentansprüche

1. Verfahren zum Herstellen eines stabilen Acetylenbrennstoffgases, bei welchem ein Metallcarbide mit einem wässrigen, flüssigen Aktivierungsreagens umgesetzt wird, welches

Wasser, ein Alkylenglykol oder einen Alkohol oder ein Gemisch hiervon als die Reaktionsgeschwindigkeit regelnde wasserlösliche Substanz und eine starke anorganische Säure enthält.

2. Verfahren nach Anspruch 1, worin das Carbide ein Erdalkalimetallcarbide ist.

3. Verfahren nach Anspruch 2, worin das Carbide Calciumcarbide ist.

4. Verfahren nach irgendeinem der Ansprüche 1 bis 3, worin das Alkylenglykol Äthylenglykol, Propylenglykol, 1,3-Propanediol, meso-2,3-Butandiol, 1,4-Butandiol, Glycerin, cis-1,2-Cyclopentandiol oder 2-Methyl-1,3-pentandiol ist.

5. Verfahren nach Anspruch 4, worin das Glykol Äthylenglykol ist.

6. Verfahren nach irgendeinem der Ansprüche 1 bis 5 worin, die starke anorganische Säure Salzsäure, Schwefelsäure, Phosphorsäure, Kohlensäure, Salpetersäure oder ein Gemisch hiervon ist.

7. Verfahren nach Anspruch 6, worin die starke anorganische Säure Salzsäure ist.

8. Verfahren nach irgendeinem der Ansprüche 1 bis 7, worin der Anteil der Säure im Reagens ausreicht, um das Entstehen eines Rückstandes aus dem Nebenprodukt Calciumhydroxid im wesentlichen zu verhindern.

9. Verfahren nach irgendeinem der Ansprüche 1 bis 8, bei welchem das flüssige Aktivierungsreagens durch Vermischen des Wassers und der Bestandteile der Substanz und Einführen der Säure in das Wasser-Substanz-Gemisch hergestellt wird.

10. Verfahren nach Anspruch 5 und 7, in welchem die Gewichtsanteile der Bestandteile des Reagens

30 bis 60% Wasser

25 bis 45% Äthylenglykol und

10 bis 45% Salzsäure (konz).

sind.

11. Verfahren nach Anspruch 5 und 7, in welchem die Gewichtsanteile der Bestandteile des Reagens

35 bis 40% Wasser

25 bis 30% Äthylenglykol und

30 bis 40% Salzsäure (konz.)

sind.

12. Verfahren nach irgendeinem der Ansprüche 1 bis 11, worin das verwendete Carbide durch das Vorliegen einer vom genannten Reagens auflösbaren luftundurchlässigen und feuchtigkeitsundurchlässigen Beschichtung gekennzeichnet ist.

13. Verfahren nach Anspruch 12, worin die Beschichtung aus Nitrocellulose und einem Polyesterharz gebildet ist.

14. Verfahren nach Anspruch 13, worin die Beschichtung durch

- (a) Inberührungbringen des Metallcarbids mit einer Aufschlammung von Nitrocellulose und einem Polyesterharz in einem organischen Lösungsmittel,
- (b) Abtrennen überschüssiger Aufschlammung von den Teilchen und
- (c) Trocknen der Teilchen durch Abdampfen des Lösungsmittels.

gebildet wird, womit die Teilchen gegenüber Luft und Feuchtigkeit undurchlässig, jedoch mit dem wässerigen flüssigen Aktivator reaktionsfähig sind.

15. Obenschmiermittel, welches ein Reaktionsnebenprodukt umfaßt, das durch Umsetzen eines Metallcarbids mit einem flüssigen Aktivierungsreagens erhalten wurde, das Wasser, ein Äthylenglykol oder einen Alkohol oder ein Gemisch hiervon als eine die Reaktionsgeschwindigkeit regelnde wasserlösliche Substanz und eine stark anorganische Säure enthält.

16. Schmiermittel nach Anspruch 15, in welchem das Äthylenglykol Äthylenglykol ist.

17. Schmiermittel nach Anspruch 15 oder Anspruch 16, in welchem die Säure Salzsäure, Schwefelsäure, Phosphorsäure, Koholensäure, Salpetersäure oder ein Gemisch hiervon ist.

18. Schmiermittel nach Anspruch 17, in welchem die Säure konzentrierte Salzsäure ist.

19. Schmiermittel nach irgendeinem der Ansprüche 15 bis 18, in welchem das Carbide Calciumcarbide ist.

20. Schmiermittel nach Anspruch 16 und 18, in welchem die Gewichtsprozentätze der Bestandteile des flüssigen Aktivierungsreagens

30 bis 60% Wasser

25 bis 45% Äthylenglykol und

10 bis 45% Salzsäure (konz.)

sind.

21. Schmiermittel nach Anspruch 16 und 18, in welchem die Gewichtsprozentätze der Bestandteile des flüssigen Aktivierungsreagens.

35 bis 40% Wasser

25 bis 30% Äthylenglykol und

30 bis 40% Salzsäure (konz.)

sind.

22. Verfahren zum Betreiben einer Brennkraftmaschine, bei welchem als Brennstoffbestandteil der Brennstoff-Luft-Beschickung der Maschine das gekäufte irgendeinem der Ansprüche 1 bis 14 hergestellte Acetylenbrennstoffgas zugeführt wird.

## Revendications

1. Procédé de production d'une gaz combustible stable à base d'acétylène, qui comporte la réaction d'un carbure métallique avec un réactif activateur liquide aqueux comprenant de l'eau, un alkylène-glycol ou un alcool ou leur mélange en tant que substance hydrosoluble influençant la vitesse de réaction, et un acide inorganique fort.

2. Procédé suivant la revendication 1, dans lequel le carbure est un carbure de métal alcalino-terreux.

3. Procédé suivant la revendication 2, dans lequel le carbure est le carbure de calcium.

4. Procédé suivant l'une quelconque des revendications 1 à 3, dans lequel alkylène-glycol est l'éthylène-glycol, le propylène-glycol, le 1,3-propane-diol, le méso-2,3-butanediol, le 1,4-butanediol, le glycérol, le cis-1,2-cyclopentane-di-ol ou le 2-méthyl-1,3-pentane-di-ol.

5. Procédé suivant la revendication 4, dans lequel le glycol est l'éthylène-glycol.

6. Procédé suivant l'une quelconque des revendications 1 à 5, dans lequel l'acide inorganique fort est l'acide chlorhydrique, sulfurique, phosphorique, carbonique ou nitrique ou un mélange de ces acides.

7. Procédé suivant la revendication 6, dans lequel l'acide inorganique fort est l'acide chlorhydrique.

8. Procédé suivant l'une quelconque des revendications 1 à 7, dans lequel la proportion d'acide dans le réactif est suffisante pour inhiber pratiquement la formation d'hydroxyde de calcium comme sous-produit résiduel.

9. Procédé suivant l'une quelconque des revendications 1 à 8, dans lequel le réactif activateur liquide est préparé par mélange de l'eau et des composants de la substance et introduction de l'acide dans le mélange eau-substance.

10. Procédé suivant les revendications 5 et 7, dans lequel les proportions en poids des composants du réactif sont les suivantes:

Eau	30 à 60%
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Ethylène-glycol	25 à 45%
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Acide chlorhydrique (concentré)	10 à 45%
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11. Procédé suivant les revendications 5 et 7, dans lequel les proportions en poids des composants du réactif sont les suivantes.

Eau	35 à 40%
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Ethylène-glycol	25 à 30%
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Acide chlorhydrique (concentré)	30 à 40%
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12. Procédé suivant l'une quelconque des

revendications 1 à 11, dans lequel le carbure qui est utilisé est caractérisé par la présence d'un revêtement imperméable à l'air et à l'humidité qui peut être dissous par ledit réactif.

13. Procédé suivant la revendication 12, dans lequel le revêtement est formé à partir de nitrocellulose et d'une résine du type polyester.

14. Procédé suivant la revendication 13, dans lequel le revêtement est formé par:

(a) mise en contact de particules de carbure métallique avec une suspension de nitrocellulose et d'une résine du type polyester dans un solvant organique;

(b) élimination de la suspension en excès des particules; et

(c) séchage des particules pour évaporer le solvant, de telle sorte que les particules soient imperméables à l'air et à l'humidité, mais soient réactives vis-à-vis de l'activateur liquide aqueux.

15. Composition de lubrifiant pour hauts de cylindres, comprenant un sous-produit réactionnel obtenu par réaction d'un carbure métallique avec un réactif activateur liquide comprenant de l'eau, un alkylène-glycol ou un alcool ou leur mélange comme substance hydro-soluble influençant la vitesse de réaction, et un acide inorganique fort.

16. Composition suivant la revendication 15, dans laquelle l'alkylène-glycol est l'éthylène-glycol.

17. Composition suivant la revendication 15 ou la revendication 16, dans laquelle l'acide est l'acide chlorhydrique, sulfurique, phosphorique, carbonique ou nitrique ou un mélange de ces acides.

18. Composition suivant la revendication 17, dans laquelle l'acide est de l'acide chlorhydrique concentré.

19. Composition suivant l'une quelconque des revendications 15 à 18, dans laquelle le carbure est le carbure de calcium.

20. Composition lubrifiante suivant les revendications 16 et 18, dans laquelle les pourcentages en poids des composants du réactif activateur liquide sont les suivants:

Eau	30 à 60%
Ethylène-glycol	25 à 45%
Acide chlorhydrique (concentré)	10 à 45%

21. Composition lubrifiante suivant les revendications 16 et 18, dans laquelle les pourcentages en poids des composants du réactif activateur liquide sont les suivants:

Eau	35 à 40%
Ethylène-glycol	25 à 30%
Acide chlorhydrique (concentré)	30 à 40%

22. Procédé pour faire fonctionner un moteur à combustion interne, qui consiste à introduire comme composant carburant de la charge carburant-air pour ledit moteur, le carburant gazeux à base d'éthylène produit par le procédé suivant l'une quelconque des revendications 1 à 14.

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