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(54) A GASOLINE COMPOSITION AND ITS PREPARATION METHOD

(57) Disclosed are a gasoline composition and its preparation method. Said gasoline composition comprises raw gasoline and acetic acid secbutyl ester, in term of the total weigh of the gasoline composition, with the contents of acetic acid secbutyl ester being 1-30 weight%, contents of the raw gasoline being 70-99 weight%. The preparation method of the gasoline composition comprises the step of adding acetic acid secbutyl ester into raw gasoline.

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Description

Field of the Invention

[0001] The present invention relates to a gasoline composition and its preparation method, particularly to a gasoline composition with a high octane number and its preparation method.

Background of the Invention

[0002] The conventional additive components which increase the octane number of a gasoline are mainly lead-containing compounds, but due to their serious environmental pollution, China has banned the production of lead-containing gasoline. At present, the octane number of a gasoline may be raised by adding aromatic compounds, oxygen-containing compounds or methylcyclopentadienyl manganese tricarbonyl (MMT).

[0003] The popular oxygen-containing compounds mainly include ether-based compounds and alcohol-based compounds. The ether-based compounds include methyl *tert*-butyl ether (MTBE), ethyl *tert*-butyl ether (ETBE) and *tert*-amyl methyl ether (TAME). Among the above ether-based compounds, MTBE is the most popular, but MTBE has the following shortcomings. Firstly, the solubility of MTBE in water is about 4.2wt%, and MTBE has a bad smell, so when the content of MTBE in water exceeds 40-95pg/L, it will make the water give off a bad smell. Secondly, MTBE is hardly biodegradable, so once the gasoline containing MTBE leaks, MTBE will stay in the environment for a long time. Considering the serious pollution of MTBE to soil and drinking water, the clean urban gasoline standard to be implemented in China in the future limits the additive amount of MTBE and specifies the content of MTBE in gasoline shall not exceed 15wt%. Alcohol-based compounds mainly include methanol, ethanol and *tert*-butanol, but alcohol-based compounds are highly soluble in water and liable to separate from gasoline when contacting water, causing negative impact on engine performance, so the use of alcohol-based compounds is limited to some extent. As aromatic compounds are liable to negative environmental impact, the content of aromatic compounds added to gasoline is strictly controlled, too.

[0004] Further, MMT is also a gasoline additive commonly used in China. MMT is an efficient anti-knock additive of lead-free gasoline, which can raise the octane number of a gasoline. The additive amount of MMT is small and its cost is low, so it is favored by users. However, the combustion product of MMT will form deposit on the spark plug of the motor, worsening the combustion condition. MMT is liable to decomposition when exposed to light, resulting in decrease of octane number during the use of gasoline. Meanwhile the generated manganese-containing waste gas will cause serious environmental pollution. Today, the use of MMT is banned in most developed countries. Chinese national stage-III motor vehicle emission standard currently adopted by China (i.e., China-III Emission Standard) also explicitly specifies the manganese content of automatic gasoline shall not be greater than 0.016g/L.

[0005] At present, people begin to focus on the application of ester-based compounds as additive components to raise the octane number of gasoline.

[0006] CN1198466A discloses an additive composition of gasoline and its production method, which is prepared by 0-5.0wt% cyclopentadiene, 0.4-1.6wt% alkenyl halide, 0-1.5wt% ethane halide, 0.3-4.0wt% ester-based compounds, 30.0-65.0wt% aromatic hydrocarbon, 0-5.0wt% enzyme, 1.0-5.0wt% organic anhydride, 0-10.0wt% castor oil, 30.00-60.0wt% solvent and 0.001-0.02wt% dye. The ester-based compounds have a general formula o fC_xCOOC_y (wherein, x is an integer from 1 to 4, and y is an integer from 1 to 3), which may be one or a mixture of two selected from the group consisting of ethyl acetate, propyl acetate, butyl acetate, dimethyl malonate, diethyl malonate and so on, wherein the mix ratio of the two ester-based compounds is genrally 1 : 1-1 : 3. Although the additive composition may raise the octane number of gasoline, the content of aromatic hydrocarbon therein is very high, so the increase of the octane number of gasoline benefits from the addition of aromatic hydrocarbon. Moreover, as the content of aromatic hydrocarbon is high, the additive composition is difficult to meet the increasingly strict environmental protection standard. Furthermore, the additive composition of gasoline has a complex composition and a complicated preparation process, which are disadvantage in cost reduction.

[0007] CN1513954A discloses a multifunctional fuel and its production method. The raw materials of the multifunctional fuel include main raw materials and auxiliary raw materials. The main raw materials include light hydrocarbon, light oil, wood alcohol, sulfonated oil, coal tar, gasoline and diesel oil. The auxiliary raw materials include ethyl stearate, potassium permanganate, sodium hydroxide, water, ethanol, hydrogen peroxide, ethyl naphthol, petroleum ether, ferrocene, acetone, toluene, phytic acid, sec-butyl acetate, butyl valerate, isoamylene, ethyl acetate, calcium hypochlorite, sodium tetraborate decahydrate, 2-phenethyl alcohol and cyclohexanone. The above auxiliary materials constitute four formulae: A, B, C and D. By chemical reactions, they play the roles of cosolvent, oxygenate, combustion improver, smoke suppressor, anti-knock agent, antistatic agent, preservative and alkane number regulator. The proportion of each formula is as follows:

Formula A: ethyl stearate 2-20wt%, potassium permanganate 3-15wt%, sodium hydroxide 2-15wt%, water 40-80wt%

and ethanol 5-30wt%;

Formula B: ethyl naphthol 5-25wt%, petroleum ether 10-30wt%, hydrogen peroxide 5-20wt%, ferrocene 5-30wt%, acetone 3-30wt% and toluene 5-30wt%;

Formula C: phytic acid 5-25wt%, *sec*-butyl acetate 3-30wt%, butyl valerate 5-30wt%, isoamylene 10-40wt%, ethyl acetate 5-20wt% and dicyandiamide 5-40wt%;

Formula D: dicyclohexylamine 2-20wt%, calcium hypochlorite 3-30wt%, sodium tetraborate decahydrate 5-35wt%, 2-phenethyl alcohol 5-50wt%, cyclohexanone 5-30wt% and polyalkenyl succinimide 5-35wt%.

[0008] By reactions, the above four formulae are made into an integrated additive E. Then according to need, additive E is added to the main materials to obtain a multifunctional fuel by reaction. Although the multifunctional fuel uses *sec*-butyl acetate, *sec*-butyl acetate is added to the multifunctional fuel as an adjuvant and its additive amount is very low, which is lower than 0.5wt%. Further, although CN1513954A also specifically discloses that during production of gasoline engine fuel, 50 parts by weight of gasoline No.70, 30 parts by weight of wood alcohol and 20 parts by weight of solvent oil No.120 may be mixed with 0.45 part of integrated additive E, it does not disclose the detailed performance index of the gasoline engine fuel.

[0009] The main problems of the fuel additive disclosed in CN1513954A lie in the following aspects. The fuel additive has many components, so the preparation process is complex and the cost is too high. Futhermore, all of formulae A, B, C and D contain olefins and the content of olefins is high, which is undesirable to the reduction of olefin content in gasoline, so they are not environment friendly.

[0010] EP0905217A discloses a lead-free gasoline, which comprises C_2-C_{15} oxygen-containing compounds, the content of the oxygen-containing compounds in gasoline makes the content of oxygen atoms is in the range of 0.1-15wt% based on the total amount of gasoline. The introduction of the oxygen-containing compounds may reduce the amount of the smoke discharged from the engine, inhibit smouldering of the spark plug and reduce carbon deposit of gasoline in the combustor. Although EP0905217A specifically discloses that the oxygen-containing compounds may be esters, the examples only disclose the gasoline respectively containing methyl *tert*-butyl ether, *tert*-amyl ethyl ether and methoxy propyl acetate, the octane numbers of which do not be increased significantly.

[0011] GB2114596A discloses a fuel composition, which comprises 3-50% by volume *tert*-butyl acetate. GB2114596A specifically discloses a fuel composition comprising 90% gasoline and 10% *tert*-butyl acetate by volume. The fuel composition has improved research octane number and motor octane number compared with the gasoline as raw material, but *tert*-butyl acetate is expensive as an upmarket chemical intermediate and is not economical as an additive component of gasoline.

[0012] Therefore, it is becoming an increasingly important research topic to develop non-hazard and cheap gasoline additives with a high octane number, a long induction period and a low gum level, thereby improving the anti-knock property of gasoline.

Summary of the Invention

[0013] To overcome the defects of the prior art, the present invention provides a cheap, pollution-free environment-friendly gasoline composition with good anti-knock property, a long induction period and a low gum level, and its preparation method, which has simple operation and low production cost.

[0014] The gasoline composition according to the present invention comprises raw gasoline and *sec*-butyl acetate, based on total amount of the gasoline composition, the *sec*-butyl acetate has a content of 1-30wt%, the raw gasoline has a content of 70-99wt%.

[0015] The preparation method of the gasoline composition according to the present invention comprises a step of adding *sec*-butyl acetate into raw material gasoline, based on total amount of the gasoline composition, the *sec*-butyl acetate is added in an amount making content of the *sec*-butyl acetate in the gasoline composition in a range of 1-30wt% and content of the raw gasoline in a range of 70-99wt%.

[0016] The gasoline composition according to the present invention uses *sec*-butyl acetate as an additive (i.e., a blending component). Compared with the existing gasoline additives, particularly with the additives used to improve the anti-knock property of a gasoline, *sec*-butyl acetate has a high octane number, low toxicity, small solubility in water and low cost, so *sec*-butyl acetate is a more efficient, environment- friendly and economical gasoline additive.

[0017] The *sec*-butyl acetate in the gasoline composition according to the present invention can raise the octane number and anti-knock index of the current gasoline, thus improving the anti-knock property of gasoline. Meanwhile, the *sec*-butyl acetate in the gasoline composition may also play a role in diluting the content of aromatic hydrocarbons in the gasoline component, thereby alleviating environmental pollution from aromatic hydrocarbon. Furthermore, the

gasoline composition containing *sec*-butyl acetate has a long induction period and a low gum level. In addition, *sec*-butyl acetate is cheap and will not increase the cost of gasoline.

[0018] Specifically, compared with the catalyzed gasoline as raw gasoline, the research octane number of the gasoline composition obtained by adding *sec*-butyl acetate in an amount of 9.8wt% to a catalyzed gasoline is increased from 90.4 to 93.0, the motor octane number is increased from 81.4 to 83.6, and the anti-knock index is increased from 85.9 to 88.3; and the induction period of the catalyzed gasoline containing *sec*-butyl acetate in an amount of 9.8wt% is greater than 600min, and the actual gum level is only 2.77mg/100mL.

[0019] The preparation method of the gasoline composition according to the present invention has no particular limitation to the purity of *sec*-butyl acetate and is highly adaptable to raw materials. Furthermore, according to the preparation method of the present gasoline composition, the *sec*-butyl acetate can be used flexibly, which may not only substitute the existing gasoline additives but also be used in combination with the existing gasoline additives. In other words, the preparation method of the gasoline composition provided by the present invention is flexible. The gasoline composition may be obtained by adding *sec*-butyl acetate into the unblended gasoline from a refinery or a chemical plant (such as a fraction of catalyzed gasoline, and a fraction of straight run gasoline), or by adding *sec*-butyl acetate into the existing finished gasoline. So, the preparation method of the present invention has a good broad spectrum and can improve the performance of both the finished gasoline on sale and the unblended gasoline.

[0020] In addition, the preparation method of the gasoline composition according to the present invention has a simple operation of adding *sec*-butyl acetate into the raw material oil and stirring evenly without complex process such as heating and reaction.

Detailed Description of the Embodiments

[0021] The gasoline composition according to the present invention comprises raw gasoline and *sec*-butyl acetate, based on total amount of the gasoline composition, the *sec*-butyl acetate has a content of 1-30wt%, the raw gasoline has a content of 70-99wt%.

[0022] *Sec*-butyl acetate is a colorless and transparent liquid, which is insoluble in water, but soluble in most organic solvents. Through research, the inventor of the present invention found *sec*-butyl acetate has excellent overall performance and is a good gasoline additive. Below, it is described in details in combination with relevant performance indices

1. Density

[0023] The density of automotive gasoline is 0.70-0.78kg/m^3 in general, and the density of *sec*-butyl acetate is 0.862kg/m^3. If added in an amount not greater than 30wt%, the added *sec*-butyl acetate has no impact on the density of automotive gasoline.

2. Octane number and anti-knock index

[0024] Octane number is an important index measuring the anti-knock property of automotive gasoline and also an important index measuring gasoline additive.

[0025] The motor octane number and the research octane number (when the octane number is 100 or below) are both determined by comparing a test sample with the knock tendency of the reference fuel with known octane number under standard conditions. The reference fuel is a mixture of *iso*-octane (the octane number is 100) and *n*-heptane (the octane number is zero). The volume percentage of *iso*-octane in the reference fuel with knocking intensity equivalent to that of the test sample is the octane number of the test sample. The motor octane number is determined in accordance with GB/T503, and the research octane number is determined in accordance with GB/T5487.

[0026] The motor octane number and the research octane number adopt basically same measurement methods and devices except the standard conditions upon measurement. The motor octane number is characterized by the harsh conditions of high temperature of the mixed gas (heated to 149°C in general) and high rotating speed of the engine (900r/min±10r/min) and is typically used to determine the anti-knock property of gasoline when the engine throttle is fully open and the engine runs at a high speed. In comparison, the research octane number is characterized by the moderately harsh conditions of low temperature of the mixed gas (not heated in general) and low rotating speed of the engine (600r/min±6r/min) and is typically used to evaluate the anti-knock property of a gasoline during transition of the engine from low speed to medium speed. As a general rule, the research octane number of a same kind of gasoline is higher than the motor octane number. The values of the research octane number and the motor octane number can be approximately converted by the following relational expression:

$$MON=RON\times 0.8+10.$$

[0027] The difference between the research octane number and the motor octane number is called gasoline sensitivity.

[0028] *Sec*-butyl acetate has a high octane number, wherein the research octane number (RON) reaches 119 and the motor octane number (MON) reaches 107, obviously higher than the octane number of the components or additives commonly used to raise the octane number of gasoline (Table 1).

Table 1

Items	Reformed gasoline	Heavy aromatic hydrocarbon	Butene alkylated oil	Ethanol	Methanol	*tert*-butyl methyl ether	ethyl *tert*-butyl ether	methyl *tert*-butyl ether	*sec*-butyl acetate
MON	88.2	94.0	95.9	96	98	98	102	99	107
RON	100.0	107.0	97.3	111	114	111	118	117	119

[0029] The motor octane number and the research octane number are both determined on a special single-cylinder engine under the standard test conditions and can hardly reflect the anti-knock property of a fuel under the running condition of a vehicle. So an empirical relationship for the anti-knock property of a fuel under the running condition of a vehicle is put forth, i.e.:

$$\text{Anti-knock index}=(\text{RON}+\text{MON})/2$$

[0030] Anti-knock index is used to reflect the average anti-knock property of a gasoline under general conditions. As the above expression indicated, the higher the octane number of gasoline is, the better its anti-knock property will be and the more obviously the power and economy of the engine will be reflected. The anti-knock index of *sec*-butyl acetate is 113, obviously higher than the anti-knock index of other gasoline additives listed in Table 1.

3. Distillation range

[0031] Vaporability is one of the most important features of a gasoline. Before entering the engine cylinder, the gasoline is firstly gasified quickly in the vaporizer and forms a combustible gas with the air. Normally, gasoline stays in the intake tube only 0.005-0.05s, and its evaporation time in the cylinder is only 0.02-0.03s. In order to form a uniform and combustible mixed gas in such a short time, the more important factor in addition to the structure and operating conditions of the gasoline engine is the vaporability of gasoline. The indices reflecting the vaporability of a gasoline are distillation range and saturated vapor pressure. In Chinese standard for the quality of automotive gasoline, distillation range indices include 10vol% evaporating temperature, 50vol% evaporating temperature, 90vol% evaporating temperature and final boiling point (i.e.: dry point).

(1) 10vol% evaporating temperature

[0032] 10vol% evaporating temperature reflects the amount of the fraction with a low boiling point in a gasoline, which has a critical influence on the easiness of starting up a gasoline engine and also has a close relation with the tendency of air lock. Lower 10vol% evaporating temperature means a larger amount of the fraction with a low boiling point in gasoline with a higher vaporability, so easier starting up a gasoline engine at low temperature. However, excessively low evaporating temperature may lead to air lock. Chinese standard for the quality of automotive gasoline requires 10vol% evaporating temperature shall not be higher than 70°C.

(2) 50vol% evaporating temperature

[0033] 50vol% evaporating temperature reflects the average vaporability of a gasoline, which has a close relation with the time for rising temperature after starting up a gasoline engine and the promptness of acceleration. The lower the 50vol% evaporating temperature of a gasoline is, the larger the evaporation capacity will be at normal temperature, thereby shortening the time for rising temperature of a gasoline engine, and making the acceleration of the engine sensitive and make its running gentle. If 50vol% evaporating temperature is too high, when the engine needs to be geared to high speed from low speed and fuel supply increases sharply, most of the gasoline cannot be gasified, resulting in incomplete combustion and even sudden flameout. Chinese standard for the quality of automotive gasoline requires 50vol% evaporating temperature shall not be higher than 120°C.

(3) 90vol% evaporating temperature and final boiling point

[0034] 90vol% evaporating temperature and final boiling point reflects the amount of heavy fraction in a gasoline. If the temperature is too high, it means the gasoline contains too much heavy fraction and it is difficult to ensure complete evaporation and complete combustion of the gasoline under the use conditions. This will lead to increase of carbon deposit in the cylinder and rise of specific fuel consumption. Moreover, the heavy gasoline fraction incompletely evaporated will also flow into the crankcase and dilute the lubricating oil, thereby increasing abrasion. Chinese standard for the quality of automotive gasoline requires 90vol% evaporating temperature shall not be higher than 190°C and final boiling point shall not be higher than 205°C.

[0035] *Sec*-butyl acetate has a boiling point of 112.3°C and has certain volatility. When added to a gasoline, the 10vol% and 50vol% evaporating temperature of the gasoline will rise slightly, while 90vol% evaporating temperature will decrease slightly. There is no negative impact on the vaporability of the gasoline composition.

4. Residue amount

[0036] The residue amount of a gasoline is also an important factor directly reflecting the quality of the gasoline, which reflects the content of the heavy components of the gasoline most difficult to vapor and the content of the oxidized gelatinous material generated in the process of storage. High residue amount will result in increment of carbon deposit in the combustor and valve assembly and serious gumming in the air intake system and the carburetor throat, thereby affecting the normal operation of the engine. China-III Emission Standard specifies the residue amount shall not be greater than 2%. *Sec*-butyl acetate basically has no residue amount, thereby having no negative impact on the residue amount of the gasoline composition.

5. Saturated vapor pressure

[0037] Under the specified conditions, when the gas phase and liquid phase of an oil product in a test unit reaches a balance, the maximum pressure of the vapor on the liquid surface is called saturated vapor pressure. Saturated vapor pressure is used to assess the evaporation intensity of a gasoline, which is an index measuring whether the gasoline can easily generate air lock in the fuel supply system of a gasoline engine, and meanwhile may also measure the loss tendency of the gasoline during storage and transport. The higher the saturated vapor pressure of a gasoline is, the higher the vaporability will be and the more easily the engine can be started up, but the greater the tendency of air lock is, the larger the evaporation loss will be. Therefore, the requirements on the saturated vapor pressure of gasoline are dependent on the atmospheric pressure and ambient temperature. China-III Emission Standard specifies gasoline vapor pressure shall not be greater than 88kPa from November 1 to April 30 of next year and not greater than 72kPa from May 1 to October 31.

[0038] When *sec*-butyl acetate is added into a gasoline, the saturated vapor pressure of the gasoline declines slightly, but the influence is small and the gasoline containing *sec*-butyl acetate can still meet the requirement of Chinese national standard.

6. Induction period

[0039] Induction period refers to the time period of an oil product keeping in a stable status under the specified conditions of accelerated oxidation, which can be determined by the method specified in GB/T8018. The summary of the method is as follows. A test sample is oxidized in an oxygen bomb, which is firstly filled oxygen to 68gkPa at 15°C-25°C then heated to 98°C-102°C. Pressure is read at a specified time interval or continuously recorded till a turning point occures. The needed time when the test sample reaches its turning point is the induction period measured at the test temperature. From the measured induction period, the induction period at 100°C may be calculated. The induction period of a gasoline is measured by minute. Apparently, if the induction period of a gasoline is long, the tendency of oxidation and gumming is small. China-III Emission Standard specifies the induction period of a gasoline shall not be smaller than 480min. The induction period of *sec*-butyl acetate is greater than 600min, so it meets the requirement of China-III Emission Standard.

7. Water-soluble acids or alkalis

[0040] Water-soluble acids are inorganic acids and low-molecule organic acids. Water-soluble alkalis refer to sodium hydroxide and *etc.* They are the residues of oil refining in general, and have strong corrosion to metal, thereby being forbidded to exist in gasoline. The content of water-soluble acids or alkalis in a gasoline may be determined in accordance with GB/T259. Summary of the method is as follows. Water-soluble acids or alkalis in a test sample are extracted with distilled water or aqueous solution of ethanol. Then methyl orange or phenolphthalein indicator is used respectively to check the color change of the extract, or the pH value is determined by a pH meter to judge the existence of water-soluble acids or alkalis. *Sec*-butyl acetate product basically contains no water-soluble acids and water-soluble alkalis, so it conforms to the relevant Chinese national standard.

8. Mechanical impurities and water

[0041] The finished gasoline refined by an oil refinery contains no mechanical impurities and water, but gasoline is inevitably contaminated by external environment during transport, storage and use, causing the entry of mechanical impurities and water into gasoline. The mechanical impurities in gasoline may block the carburetor jet and the gasoline filter, meanwhile intensify the abrasion of the carburetor jet and the cylinder piston assembly. The water in gasoline may be frozen in winter, which may block the filter or fuel way in serious cases, resulting in interruption of fuel supply. In addition, water may also accelerate the corrosion of parts, dissolve antioxidant, accelerating gasoline oxidation to generate gum, result in decomposition of lead tetraethyl and make the additives such as export agent lose effect. The

common method to check the mechanical impurities and water in gasoline is performed by putting a test sample into a 100mL glass measuring cylinder and keeping it stand 8-12h. The test sample shall remain transparent and have no suspended and settled mechanical impurities and water. When there is dissent, mechanical impurities may be determined by the method specified in GB/T511 and water may be determined by the method specified in GB/T260. It is determined by test that *sec*-butyl acetate contains no suspended or settled mechanical impurities and water.

9. Content of aromatic hydrocarbon

[0042] During production of *sec*-butyl acetate, no aromatic hydrocarbon is generated, so the content of aromatic hydrocarbon in *sec*-butyl acetate is zero.

10. Olefin content

[0043] The standard for the quality of automotive gasoline specifies olefin content shall be smaller than or equal to 30vol%. Although a small amount of olefin is generated during the production of *sec*-butyl acetate, the olefin content is low and the influence on the increasing of olefin content of the gasoline is non-significant.

11. Oxygen content

[0044] The limitation to oxygen content in automotive gasoline is mainly from the consideration of calorific value. With the increasing of oxygen content in a gasoline, the effective combustible components in the gasoline will decrease, thus reducing calorific value and impairing the power of the engine. In addition, if the oxygen content in gasoline is too high, the carbon deposit in the cylinder will decrease, which makes the exhaust valve of the cylinder lose the protection of carbon deposit, leading to more seriouse abrasion. In the prevailing automotive gasoline standard, the oxygen content in gasoline shall be lower than 2.7wt%. Although the oxygen content of *sec*-butyl acetate is 27.6wt%, the gasoline containing *sec*-butyl acetate may meet the requirement of automotive gasoline standard by controlling the additive amount of *sec*-butyl acetate in gasoline.

12. Iron content

[0045] No iron devices are used during the production of *sec*-butyl acetate, so *sec*-butyl acetate product contains no iron.

13. Existent gum

[0046] Existent gum is typically used to indicate the tendency of deposit formation of gasoline in the intake pipeline and intake valve, which is the gasoline evaporation residue insoluble in *n*-heptane determined under the specified conditions. It may be determined in accordance with GB/T8019. The summary of the method is as follows. A known amount of fuel is evaporated under the condition of controlled temperature and controlled air. The residues before extracted by *n*-heptane and after extracted by *n*-heptane are weighed respectively. The obtained results are reported by mg/100mL. In this way, the existent gum of the gasoline is determined. China-III Emission Standard specifies the existent gum of a gasoline shall not be greater than 5mg/100mL at the time of leaving the factory. The existent gum of *sec*-butyl acetate is only 0.5-1.2mg/100mL, so it conforms to the requirement of China-III Emission Standard.

14. Doctor test

[0047] Doctor test refers to a test in which sodium plumbite reacts with light oil products under the existence of sublimed sulfur to check mercaptan or hydrogen sulfide in oil, which may be determined by the method specified in SH/T0174. The methodological principle of the doctor test is as follows. 10mL of a test sample and 5mL of a sodium plumbite solution are put into a 50mL measuring cylinder with ground stopper and shaken violently. If the test sample contains hydrogen sulfide, black lead sulfide will be produed. If there is no the above reaction, then a little amount of pure and dry sublimed sulfur powder is added and the mixture is shaken again. If the test sample contains mercaptan, the color of the oil layer and sulfur membrane will be changed after a series of reactions. *Sec*-butyl acetate has passed the doctor test.

15. Copper strip corrosion (50°C, 3h)

[0048] Under specified conditions, the copper corrosion tendency of the oil product is tested and whether gasoline contains free sulfur and activated sulfide is checked. It is determined by the method specified in GB/T5096. The summary

of the method is as follows. A polished copper strip is immersed into a certain amount of a test sample and heated to the designated temperature according to the product standard, and is kept for a specific time at the temperature. When the test cycle ends, the copper strip is taken out and is compared with the standard color palettes of corrosion to determine corrosion level after washed. There are four levels of standard color palettes: level 1 means slight color change; level 2 means moderate color change; level 3 means serious color change; and level 4 means corrosion. The copper strip corrosion (50°C, 3h) of a gasoline specified in China-III Emission Standard shall not be greater than level 1. The copper strip corrosion of *sec*-butyl acetate is 1a, so it conforms to the requirement of China-III Emission Standard.

16. Sulfur content

[0049] Sulfur content refers to the content of sulfur and its derivatives in a gasoline (such as: hydrogen sulfide, mercaptan and bisulfide), which is expressed by mass percentage. When the sulfur and its deratives in a gasoline meet water or vapor, sulfurous acid and sulfuric acid will be produced. Under the condition of gasoline combustion, this tendency is even stronger. Sulfurous acid and sulfuric acid are highly corrosive to metals. In addition, sulfur can also reduce the octane number of gasoline and the perceptibility of gasoline to lead tetraethyl (i.e.: weaken the increment amplitude of octane number of gasoline by the addition of lead tetraethyl). Therefore, China-III Emission Standard specifies sulfur content shall not be greater than 150ppm. Sulfur content may be determined by the method specified in GB/T380.

[0050] The sulfur content of *sec*-butyl acetate is very low. When the sulfur content is below 3ppm, it is very suitable to produce clean gasoline fuel containing little or no sulfur.

17. Methanol content

[0051] No methanol is produced during the production of *sec*-butyl acetate and the raw materials contain no methanol, either. So, the content of methanol in *sec*-butyl acetate product is 0.

18. Benzene content

[0052] Benzene is a highly hazardous chemical product. The automotive gasoline standard specifies the content of benzene shall not be greater than 1.0vol%. Benzene content may be determined by the method specified in SH/T0693. When there is objection to the determination of benzene content, the result determined by the method specified in SH/T0713 shall prevail. According to the determination result, *sec*-butyl acetate product contains no benzene.

19. Manganese content

[0053] Manganese content refers to the total content of manganese existing in form of methylcyclopentadienyl manganese tricarbonyl (MMT) in gasoline. No other types of manganese-containing additives shall be added. China-III Emission Standard specifies manganese content shall not be greater than 0.016g/L, which is determined by the method specified in SH/T0711. Beijing Gasoline Emission Standard C specifies manganese content shall not be greater than 0.006g/L. According to the determination result, *sec*-butyl acetate product contains no manganese.

[0054] The foregoing analysis results indicate *sec*-butyl acetate has superior performance indices and is a good gasoline additive.

[0055] The gasoline composition according to the present application, based on the total amount of the gasoline composition, the *sec*-butyl acetate may have a content of 1-30wt%. When the content of *sec*-butyl acetate in the gasoline composition is lower than 1wt%, it is difficult to achieve a desirable effect of raising octane number and anti-knock index of a gasoline. When the content of *sec*-butyl acetate in the gasoline composition is higher than 30wt%, the gasoline composition will become more corrosive to the rubber washers in the fuel filling pipes and fuel guns of gasoline stations and the rubber oil conduits of gasoline engines. From the perspective of further lowering the corrosion to the rubber products contacting the gasoline composition and controlling the oxygen content of the gasoline composition, based on the total amount of the gasoline composition, the *sec*-butyl acetate preferably has a content of 2-10wt%.

[0056] The raw gasoline in the gasoline composition according to the present invention may be various kinds of raw gasoline popular in the art, without particular limitation. Specifically, the raw gasoline may be commercial finished gasoline containing various kinds of additives, such as gasoline No. 90, gasoline No. 93 or gasoline No. 97; or the gasoline fraction from an oil refinery or a chemical plant, such as catalytically cracked gasoline, alkylated gasoline, reformed gasoline, reformed raffinate oil, hydrotreated coker gasoline, straight run gasoline or light hydrocarbon C5. The light hydrocarbon C5 refers to various kinds of hydrocarbons containing five carbon atoms as well as their mixtures.

[0057] The raw gasoline in the gasoline composition according to the present invention may also contain one or more selected from the group consisting of ether-based compounds, alcohol-based compounds and aromatic hydrocarbons.

Based on the total amount of the gasoline composition, total amount of the ether-based compounds, the alcohol-based compounds and the aromatic hydrocarbons is 0.02-33wt%.

[0058] The aromatic hydrocarbons may be various kinds of aromatic hydrocarbons popular in the art, without particular limitation. Preferably, the aromatic hydrocarbons are one or more selected from the group consisting of benzene, toluene, ethylbenzene, xylene (including *o*-xylene, m-xylene and *p*-xylene), trimethylbenzene (including all the isomers of trimethylbenzene) and C10 aromatic hydrocarbons. The C10 aromatic hydrocarbons refer to the aromatic hydrocarbons with 10 carbon atoms as well as their mixture. Based on the total amount of the gasoline composition, the aromatic hydrocarbons preferably have a content of 0.02-33wt%. From the perspective of environmental protection, based on the total amount of the gasoline composition, the benzene preferably has a content of 0.01-0.88wt%.

[0059] The ether-based ompounds may be various kinds of ethers well known to those skilled in the art. Preferably, the ether-based compounds are one or more selected from the group consisting of methyl *tert*-butyl ether, ethyl *tert*-butyl ether, *tert*-amyl methyl ether and dibutyl ether. Preferably, based on the total amount of the gasoline composition, the ether-based compounds have a content of 0.1-15wt%.

[0060] The alcohol-based compounds may be various kinds of alcohol compounds popular in the art. Preferably, the alcohol-based compounds are one or more selected from the group consisting of methanol, ethanol, *n*-butanol, *sec*-butanol and *tert*-butanol. Based on the total amount of the gasoline composition, the alcohol-based compounds preferably have a content of 0.02-10wt%.

[0061] The performance indices of the gasoline composition according to the present invention conform to national automotive gasoline standard III (GB17930-2006 (III) (Table 2). The gasoline composition not only has a high octane number but also is pollution free and environmental friendly.

Table 2

Items	Quality indices		
	No. 90	No. 93	No. 97
Research octane number (RON)	≥90	≥93	≥97
Anti-knock index (RON+MON)/2	≥85	≥88	/
Lead content (g/L)	≤0.005		
10vol% evaporating temperature (°C)	≤70		
50vol% evaporating temperature (°C)	≤120		
90vol% evaporating temperature (°C)	≤190		
Final boiling point (°C)	≤205		
Residue amount (vol%)	≤2		
Vapor pressure (from November 1 to April 30) (kPa)	≤88		
Vapor pressure (from May 1 to October 31) (kPa)	≤72		
Induction period (min)	≥480		
Water-soluble acid or alkali	not detected		
Mechanical impurities and water	not detected		
Aromatic hydrocarbon content (vol%)	≤40		
Olefin content (vol%)	≤30		
Oxygen content (wt%)	≤2.7		
Iron content (g/L)	≤0.01		
Existent gum (mg/100mL)	≤5		
Doctor test	Pass		
Copper strip corrosion (50°C, 3h) (level)	≤1		
Sulfur content (wt%)	≤0.015		
Methanol content (wt%)	≤0.3		

(continued)

Items	Quality indices		
	No. 90	No. 93	No. 97
Benzene content (vol%)	≤1.0		
Manganese content (g/L)	≤0.016		

[0062] The present invention further provides a preparation method of the gasoline composition, which comprises a step of adding *sec*-butyl acetate into raw material gasoline, based on the total amount of the gasoline composition, the *sec*-butyl acetate is added in an amount making cotent of the *sec*-butyl acetate in the gasoline composition in a range of 1-30wt% and making content of the raw gasoline in a range of 70-99wt%.

[0063] The present invention has no particular limitation to the method for adding *sec*-butyl acetate into raw material gasoline. It may be any one of the methods well known to those skilled in the art as long as it may ensure the raw gasoline and *sec*-butyl acetate are mixed evenly and the content of *sec*-butyl acetate is within the specified range. For example, a predetermined amount of *sec*-butyl acetate may be added into raw gasoline in a mixer under stirring; or *sec*-butyl acetate and raw gasoline may be simultaneously added to a mixer and stirred them evenly.

[0064] According to the preparation method of the gasoline composition of the present invention, based on the total amount of the gasoline composition, the *sec*-butyl acetate is added in an amount making content of the *sec*-butyl acetate in the gasoline composition in a range of 1-30wt%. Preferably, based on the total amount of the gasoline composition, the *sec*-butyl acetate is added in an amount making content of the *sec*-butyl acetate in the gasoline composition in a range of 2-10wt%.

[0065] As *sec*-butyl acetate can obviously enhance the overall performance of a gasoline, in particular octane number, and has no strict requirement on the purity of *sec*-butyl acetate per se, the present invention has no particular limitation to the source of *sec*-butyl acetate. It may be any commercial *sec*-butyl acetate. From the perspective of further lowering the content of olefin in the gasoline composition and raising the octane number of the gasoline composition, the purity of *sec*-butyl acetate may be 80wt% or above, preferably 90wt% or above, more preferably 97.5wt% or above and still more preferably 99wt% or above. When the purity of *sec*-butyl acetate is within the foregoing range, it can not only ensure that the content of olefin in the gasoline composition conforms to China-III Emission Standard but also make the octane number of the gasoline composition meet use requirements and lower the cost of the gasoline composition.

[0066] The preparation method of the gasoline composition according to the present invention may further comprise a step of adding one or more selected from the group consisting of ether-based compounds, alcohol-based compounds and aromatic hydrocarbons into raw material gasoline. Based on the total amount of the gasoline composition, total amount of the ether-based compounds, the alcohol-based compounds and the aromatic hydrocarbons in the gasoline composition is 0.02-33wt%.

[0067] The present invention has no particular limitation to the addition sequence of *sec*-butyl acetate, ether-based compounds, alcohol-based compounds and aromatic hydrocarbons. The step of adding one or more selected from the group consisting of ether-based compounds, alcohol-based compounds and aromatic hydrocarbons into raw gasoline and the step of adding *sec*-butyl acetate into raw gasoline can realize the objective of the present invention when various sequences are used.

[0068] The present invention has no particular limitation to the additive amount of the ether-based compounds, alcohol-based compounds and aromatic hydrocarbons, and the additive amount may be a conventional amount in the art as long as the total amount of ether-based compounds, alcohol-based compounds and aromatic hydrocarbons in the gasoline composition is 0.02-33wt% based on the total amount of the gasoline composition. Anyway, from the perspectives of environmental protection and cost reduction, the ether-based compounds are added in an amount making total content of the ether-based compounds in the gasoline composition in a range of 0.1-15wt%, the alcohol-based compounds are added in an amount making total content of the alcohol-based compounds in the gasoline composition in a range of 0.02-10wt%, and the aromatic hydrocarbons are added in an amount making total content of the aromatic hydrocarbons in the gasoline composition in a range of 0.02-33wt%. From the perspective of environmental protection, based on the total amount of the gasoline composition, the benzene in the aromatic hydrocarbons are added in an amount making total content of the benzene in the gasoline composition in a range of 0.01-0.88wt%.

[0069] The types of the ether-based compounds, alcohol-based compounds and aromatic hydrocarbons added to the gasoline composition have been described hereinbefore, so it is omitted herein.

[0070] Below the present invention will be described in more details in connection with examples.

[0071] In the following embodiments, tests are done by the method specified in Chinese national standard GB17930-2006 (III).

Example 1

[0072] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0073] *Sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd and has a purity of 97.8wt%, the physical and chemical parameters of which are listed in Table 3.

[0074] 2 parts by weight of *sec*-butyl acetate are added into 98 parts by weight of raw gasoline (hydrogenated gasoline from catalytic cracking provided by Sinopec Changling Branch) and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 2wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 3.

Example 2

[0075] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0076] The raw gasoline and *sec*-butyl acetate used in this example is same as those in Example 1.

[0077] 5.1 parts by weight of *sec*-butyl acetate are added into 94.9 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 5wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 3.

Example 3

[0078] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0079] The raw gasoline and *sec*-butyl acetate used in this example is same as those in Example 1.

[0080] 10 parts by weight of *sec*-butyl acetate are added into 90 parts by weight of raw gasoline and mixed evenly, so as to obain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 9.8wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 3.

Example 4

[0081] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0082] The raw gasoline and *sec*-butyl acetate used in this example is same as those in Example 1.

[0083] 30.7 parts by weight of *sec*-butyl acetate are added into 69.3 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 30wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 3.

Comparative Example 1

[0084] The raw gasoline and *sec*-butyl acetate used is same as those in Example 1.

[0085] 0.5 part by weight of *sec*-butyl acetate is added into 99.5 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition. In the obtained gasoline composition, the content of *sec*-butyl acetate is 0.5wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 3.

Comparative Example 2

[0086] The raw gasoline and *sec*-butyl acetate used is same as those in Example 1.

[0087] 35.8 parts by weight of *sec*-butyl acetate are added into 64.2 parts by weight of raw gasoline and mixed well, so as to obtain a gasoline composition. In the obtained gasoline composition, the content of *sec*-butyl acetate is 35wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 3.

Table 3

Analytical items	Test results							
	Catalyzed gasoline	*sec*-butyl acetate	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparaive Example 2
Density (kg/m^3)	722.0	860.0	724.7	728.8	735.5	762.5	722.2	770.3
10vol% evaporating temperature (°C)	40.5	-	40.9	42.5	44.5	52.5	40.6	55.0
50vol% evaporating temperature (°C)	86.7	-	87.0	90.5	93.5	97.5	86.8	99.8
90vol% evaporating temperature (°C)	154.3	-	153.6	152.0	150.0	146.8	154.2	144.5
Final boiling point (°C)	191.0	-	189.6	187.5	185.0	181.2	190.8	178.6
Residue amount (vol%)	1.5	-	1.5	1.5	1.5	1.5	1.5	1.5
Full efflux (vol%)	97.5	-	97.5	97.5	97.5	97.5	97.5	97.5
Aromatic hydrocarbon (vol%)	26.5	0	26.0	25.2	23.9	18.6	26.4	17.2
Olefin (vol%)	31.9	2.0	30.7	30.4	28.9	22.9	31.7	21.4
Doctor test	pass	pass	pass	pass	pass	pass	pass	pass
Total sulfur (wt%)	0.016	0	0.016	0.015	0.014	0.011	0.016	0.010
MON	81.4	104	81.8	82.4	83.6	87.0	81.5	87.5
RON	90.4	117	91.0	91.6	93.0	97.5	90.5	98.0
Anti-knock index	85.9	110.5	86.4	87.0	88.3	92.3	86.0	92.8
Water-soluble acid or alkali	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected
Vapor pressure (kPa)	68.5	4.2	67.0	65.0	63.0	50.5	68.2	49.0
Oxygen content (wt%)	0.1	27.0	0.6	1.4	2.7	8.2	0.2	9.5
Methanol content (wt%)	0.01	0	0.01	0.01	0.01	0.01	0.01	0.01
Benzene content (vol%)	0.68	0	0.67	0.65	0.61	0.48	0.68	0.44
Existent gum (mg/100mL)	3.0	0.7	2.95	2.89	2.77	2.31	2.99	2.2

(continued)

Analytical items	Test results							
	Catalyzed gasoline	*sec*-butyl acetate	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparaive Example 2
Copper strip corrosion	1a	1a	1a	1a	1a	1a	1a	1a
Induction period (min)	560	>600	>600	>600	>600	>600	>600	>600

[0088] The result in Table 3 indicates that the gasoline composition containing *sec*-butyl acetate in a content of 2-30wt% has a higher octane number and anti-knock index.

Example 5

[0089] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0090] The raw gasoline used in this example is same as that in Example 1.

[0091] *Sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity of 98.5wt%, the performance indices of which are listed in Table 4.

[0092] 8.1 parts by weight of *sec*-butyl acetate are added into 91.9 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 8wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 4.

Comparative Example 3

[0093] The raw gasoline used in this comparative example is same as that in Example 1. The methyl *tert*-butyl ether used in this comparative example is purchased from Shanghai Yuanjing Chemicals Co., Ltd. and has a purity of 98.5wt%.

[0094] 8.1 parts by weight of methyl *tert*-butyl ether are added into 91.9 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition containing methyl *tert*-butyl ether. In the obtained gasoline composition, the content of methyl *tert*-butyl ether is 8wt%. The technical indices of the obtained gasoline composition containing methyl *tert*-butyl ether are listed in Table 4.

Comparative Example 4

[0095] The raw gasoline used in this comparative example is same as that in Example 1. The *n*-butyl acetate used in this comparative example is purchased from Wuxi Baichuan Chemical Industry Co., Ltd. and has a purity of 98.5wt%.

[0096] 8.1 parts by weight of *n*-butyl acetate are added into 91.9 parts by weight of raw material gasoline and mixed evenly, so as to obtain a gasoline composition containing *n*-butyl acetate. In the obtained gasoline composition, the content of *n*-butyl acetate is 8wt%. The technical indices of the obtained gasoline composition containing *n*-butyl acetate are listed in Table 4.

Comparative Example 5

[0097] The raw gasoline used in this comparative example is same as that in Example 1. The *tert*-butyl acetate used in this comparative example is purchased from Shanghai Cyclobase Fine-Chemical Co., Ltd. and has a purity of 98.5wt%.

[0098] 8.1 parts by weight of *tert*-butyl acetate are added into 91.9 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition containing *tert*-butyl acetate. In the obtained gasoline composition, the content of *tert*-butyl acetate is 8wt%. The technical indices of the obtained gasoline composition containing *tert*-butyl acetate are listed in Table 4.

Table 4

Analytical items	Test results						
	Catalyzed gasoline	*sec*-butyl acetate	methyl *tert*-butyl ether	Example 5	Comparative Example 3	Comparative Example 4	Comparative Example 5
Density (kg/m^3)	722.0	862.0	739.5	733.0	723.4	734.4	736.2
10vol% evaporating temperature (°C)	40.5	-	-	44.2	41.5	44.5	43.6
50vol% evaporating temperature (°C)	86.7	-	-	91.0	83.8	91.5	88.5
90vol% evaporating temperature (°C)	154.3	-	-	150.4	146.2	150.9	149.2
Final boiling point (°C)	191.0	-	-	185.4	180.2	186.0	183.2
Residue amount (vol%)	1.5	-	1.5	1.5	1.5	1.5	1.5
Full efflux (vol%)	97.5	-	97.5	97.5	97.5	97.5	97.5
Aromatic hydrocarbon (vol%)	26.5	0	0	24.4	24.4	24.4	24.4
Olefin (vol%)	31.9	1.2	0.5	29.4	29.4	29.3	29.3
Doctor test	pass	pass	pass	pass	pass	pass	pass
Total sulfur (wt%)	0.016	0	0.013	0.015	0.016	0.015	0.015
MON	81.4	106	99	83.4	83.0	82.5	84.0
RON	90.4	119	117	93.0	92.8	92.0	94.0
Anti-knock index	85.9	112	109	88.2	87.9	87.3	89.0
Water-soluble acid or alkali	not detected	not detected	not detected	not detected	not detected	not detected	not detected
Vapor pressure (kPa)	68.5	4.6	55	64.8	67.8	63.5	-
Oxygen content (wt%)	0.1	27.2	18.2	2.3	1.5	2.3	2.3
Methanol content (wt%)	0.01	0	0.08	0.01	0.02	0.01	0.01
Benzene content (vol%)	0.68	0	0	0.63	0.63	0.63	0.63

(continued)

Analytical items	Test results						
	Catalyzed gasoline	*sec*-butyl acetate	methyl *tert*-butyl ether	Example 5	Comparative Example 3	Comparative Example 4	Comparative Example 5
Existent gum (mg/100mL)	3.0	0.6	1.0	2.8	2.8	2.8	3.0
Copper strip corrosion	1a	1a	1a	1a	1a	1a	1a
Induction period (min)	560	>600	>600	>600	>600	>600	>560 but <600

[0099] The result in Table 4 indicates that compared with the gasoline composition containing methyl *tert*-butyl ether and the gasoline composition containing *n*-butyl acetate, the gasoline composition containing *sec*-butyl acetate has higher octane number and anti-knock index. Compared with the gasoline composition containing *tert*-butyl acetate, the gasoline composition containing *sec*-butyl acetate has less existent gum and a longer induction period. Further, the density of the gasoline composition containing *sec*-butyl acetate is lower than the gasoline composition containing *tert*-butyl acetate, therefore, *sec*-butyl acetate is more suitable for blending with gasoline.

Example 6

[0100] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0101] The *sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity of 80wt%.

[0102] 6.3 parts by weight of *sec*-butyl acetate are added into 93.7 parts by weight of raw gasoline (commercial gasoline No. 90) and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 5wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 5.

Example 7

[0103] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0104] The raw gasoline used in this example is same as that in Example 6. The *sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity of 90wt%.

[0105] 5.6 parts by weight of *sec*-butyl acetate are added into 94.4 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 5wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 5.

Example 8

[0106] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0107] The raw gasoline used in this example is same as that in Example 6. The *sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity of 97.5wt%.

[0108] 5.1 parts by weight of *sec*-butyl acetate are added into 94.9 parts by weight of raw gasoline and mixed well, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 5wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 5.

Example 9

[0109] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0110] The raw gasoline used in this example is same as that in Example 6. The *sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity of 99wt%.

[0111] 5.1 parts by weight of *sec*-butyl acetate are added into 94.9 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 5wt%. The technical indices of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 5.

Table 5

Analytical items	Test results				
	gasoline No. 90	Example 6	Example 7	Example 8	Example 9
Density (kg/m^3)	702.3	709.1	709.8	710.4	710.5
10vol% evaporating temperature (°C)	39.5	41.0	42.5	43.8	44.2

(continued)

Analytical items	Test results				
	gasoline No. 90	Example 6	Example 7	Example 8	Example 9
50vol% evaporating temperature (°C)	79.5	80.3	82.0	83.5	83.8
90vol% evaporating temperature (°C)	136.5	135.9	135.0	134.5	134.1
Final boiling point (°C)	175.6	171.2	169.5	168.8	168.4
Residue amount (vol%)	1.5	1.5	1.5	1.5	1.5
Full efflux (vol%)	97.5	97.5	97.5	97.5	97.5
Aromatic hydrocarbon (vol%)	32.1	30.5	30.5	30.5	30.5
Olefin (vol%)	15.4	15.6	15.1	14.7	14.7
Doctor test	pass	pass	pass	pass	pass
Total sulfur (wt%)	0.016	0.015	0.015	0.015	0.015
MON	81.0	81.4	82.0	82.3	82.5
RON	90.2	90.7	91.2	91.5	91.7
Anti-knock index	85.6	86.1	86.6	86.9	87.1
Water-soluble acid or alkali	not detected	not detected	not detected	not detected	not detected
Vapor pressure (kPa)	72.5	69.0	69.2	69.4	69.5
Oxygen content (wt%)	0.5	1.6	1.7	1.8	1.9
Methanol content (wt%)	0.01	0.01	0.01	0.01	0.01
Benzene content (vol%)	0.52	0.49	0.49	0.49	0.49
Existent gum (mg/100mL)	2.5	2.4	2.4	2.4	2.4
Copper strip corrosion	1a	1a	1a	1a	1a
Induction period (min)	>600	>600	>600	>600	>600

[0112] The result in Table 5 indicates that the preparation method of the gasoline composition according to the present invention have no particular limitation to the purity level of *sec*-butyl acetate and the *sec*-butyl acetate with a purity level not lower than 80wt% is acceptable. So the preparation method of the gasoline composition according to the present invention is highly adaptable to raw materials.

Example 10

[0113] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0114] The *sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity of 99.5wt%, the octane number and anti-knock index of which are listed in Table 6.

[0115] 8 parts by weight of *sec*-butyl acetate are added to 92 parts by weight of raw gasoline (light hydrocarbon C5 provided by CNOOC and Shell Petrochemicals Company Limited) and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 8wt%. The octane number and anti-knock index of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 6.

Example 11

[0116] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0117] The *sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity of 80wt%, the octane number and anti-knock index of which are listed in Table 6.

[0118] 37.5 parts by weight of *sec*-butyl acetate are added into 62.5 parts by weight of raw gasoline (straight run gasoline provided by Sinopec Changling Branch) and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 30wt%. The octane number and anti-knock index of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 6.

Example 12

[0119] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0120] The *sec*-butyl acetate used in the example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity of 90wt%, the octane number and anti-knock index of which are listed in Table 6.

[0121] 16.7 parts by weight of *sec*-butyl acetate are added into 83.3 parts by weight of raw gasoline (reformed raffinate oil provided by Sinopec Shanghai Branch) and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 15wt%. The octane number and anti-knock index of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 6.

Example 13

[0122] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0123] The *sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity of 95wt%, the octane number and anti-knock index of which are listed in Table 6.

[0124] 2.1 parts by weight of *sec*-butyl acetate are added into 97.9 parts by weight of raw gasoline (reformed gasoline provided by Sinopec Changling Branch) and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 2wt%. The octane number and anti-knock index of the obtained gasoline composition containing *sec*-butyl acetate are listed in Table 6.

Table 6

Analytical items	Test results											
	sec-butyl acetate 99.5%	Light hydrocarbon C5	Example 10	*sec*-butyl acetate 80%	straight run gasoline	Example 11	*sec*-butyl acetate 90%	Reformed raffinate oil	Example 12	*sec*-butyl acetate 95%	Reformed gasoline	Example 13
MON	107	72	76.6	90	55	69.5	98	68	74.5	103	98	98.2
RON	119	83	87.7	101	56	74	110	70	77.5	115	105	105.2
Anti-knock index	113	77.5	82.2	95.5	55.5	71.8	104	69	76	109	101.5	101.7

[0125] The result in Table 6 indicates that the preparation method of the gasoline composition according to the present invention may be used to raise the octane number of the raw gasoline from various sources and has a good broad spectrum.

Example 14

[0126] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0127] The *sec*-butyl acetate used in this example is purchased from Hunan Zhongchuang Chemical Co., Ltd. and has a purity 95wt%, the physical and chemical parameters of which are listed in Table 7.

[0128] 10.5 parts by weight of *sec*-butyl acetate and 10 parts by weight of toluene (purchased from Sinopec Changling Refinery, purity 98.5wt%) are added into 79.5 parts by weight of raw gasoline (hydrogenated gasoline from catalytic cracking purchased from Sinopec Changling Branch) respectively, and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 10wt% and the content of toluene is 10wt%. The technical indices of the obtained gasoline composition are listed in Table 7.

Comparative Example 6

[0129] A gasoline composition is obtained by the method same as Example 14, except that no *sec*-butyl acetate is added and 20.5 parts by weight of toluene is added into 79.5 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition. The technical indices of the obtained gasoline composition are listed in Table 7.

Example 15

[0130] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0131] The *sec*-butyl acetate and raw material gasoline used in this example is same as those in Example 14.

[0132] 2.1 parts by weight of *sec*-butyl acetate and 2 parts by weight of methyl *tert*-butyl ether (purchased from Shanghai Yuanjing Chemicals Co., Ltd., purity 98.5wt%) are added to 95.9 parts by weight of raw material gasoline and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obained gasoline composition, the content of *sec*-butyl acetate is 2wt% and the content of methyl *tert*-butyl ether is 2wt%. The technical indices of the obtained gasoline composition are listed in Table 7.

Comparative Example 7

[0133] A gasoline composition is obtained by the method same as Example 15, except that no *sec*-butyl acetate is added, and 4.1 parts by weight of methyl *tert*-butyl ether is added to 95.9 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition. The technical indices of the obtained gasoline composition are listed in Table 7.

Example 16

[0134] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0135] The *sec*-butyl acetate and raw gasoline used in this example is same as those in Example 14.

[0136] 5.3 parts by weight of *sec*-butyl acetate and 3 parts by weight of ethanol (purchased from Henan Tianguan Fuel Ethanol Co., Ltd., purity 98.5wt%) are added into 91.7 parts by weight of raw gasoline and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 5wt% and the content of ethanol is 3wt%. The technical indices of the obtained gasoline composition are listed in Table 7.

Comparative Example 8

[0137] A gasoline composition is obtained by the method same as Example 16, except that no *sec*-butyl acetate is added, and 8.3 parts by weight of ethanol is added into 91.7 parts by weight of raw gasoline and mixed evenly, so as to obatin the gasoline composition. The technical indices of the obtained gasoline composition are listed in Table 7.

Table 7

Analytical items	Test results							
	Catalyzed gasoline	*sec*-butyl acetate	Example 14	Example 15	Example 16	Comparative Example 6	Comparative Example 7	Comparative Example 8
Density (kg/m^3)	722.0	855.5	750.5	725.2	731.1	751.7	722.7	727.6
10vol% evaporating temperature (°C)	40.5	-	45.0	40.0	43.2	44.8	39.5	41.3
50vol% evaporating temperature (°C)	86.7	-	95.0	88.0	88.5	94.5	87.2	86.5
90vol% evaporating temperature (°C)	154.3	-	152.0	153.0	150.2	151.0	151.5	147.6
Final boiling point (°C)	191.0	-	187.0	189.0	182.3	185.5	187.0	178.8
Residue amount (vol%)	1.5	-	1.5	1.5	1.5	1.5	1.5	1.5
Full efflux (vol%)	97.5	-	97.5	97.5	97.5	97.5	97.5	97.5
Aromatic hydrocarbon (vol%)	26.5	0	31.1	25.4	24.3	41.6	25.4	24.3
Olefin (vol%)	31.9	4.6	26.4	30.8	29.5	30.6	25.4	29.5
Doctor test	pass	pass	pass	pass	pass	pass	pass	pass
Total sulfur (wt%)	0.016	0	0.013	0.015	0.015	0.013	0.016	0.015
MON	81.4	102	85.0	82.9	83.2	85.5	82.0	82.5
RON	90.4	115	94.5	91.2	92.3	95.0	91.0	92.0
Anti-knock index	85.9	108.5	89.8	87.1	87.8	90.3	86.5	87.3
Water-soluble acid or alkali	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected
Vapor pressure (kPa)	68.5	4.2	60.0	66.0	63.4	55.2	66.5	64.0
Oxygen content (wt%)	0.1	26.2	2.5	0.86	2.3	0.1	0.84	3.0
Methanol content (wt%)	0.01	0	0.01	0.01	0.01	0.009	0.013	0.008
Benzene content (vol%)	0.68	0	0.54	0.68	0.63	0.54	0.68	0.63

(continued)

Analytical items	Test results							
	Catalyzed gasoline	*sec*-butyl acetate	Example 14	Example 15	Example 16	Comparative Example 6	Comparative Example 7	Comparative Example 8
Existent gum (mg/100mL)	3.0	1.2	2.5	2.9	2.8	2.4	2.9	2.8
Copper strip corrosion	1a	1a	1a	1a	1a	1a	1a	1a
Induction period (min)	560	>600	>600	>600	>600	>600	>600	>600

[0138] The result in Table 7 indicates that *sec*-butyl acetate may be used in combination with other gasoline additives. By comparing Example 14 with Comparative Example 6, it can be seen that *sec*-butyl acetate not only may be used to raise the octane number and anti-knock index of gasoline, but also may be used to dilute the aromatic hydrocarbon in gasoline. By comparing Example 15 with Comparative Example 7 and comparing Example 16 with Comparative Example 8, it can be seen that under the condition of a same additive amount, the gasoline composition containing *sec*-butyl acetate has a higher octane number and anti-knock index.

Example 17

[0139] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0140] The *sec*-butyl acetate and raw gasoline used in this example is same as those in Example 5.

[0141] 5 parts by weight of *sec*-butyl acetate, 5 parts by weight of ethyl *tert*-butyl ether (purchased from Guangzhou Weibo Chemical Co., Ltd., purity 98.5wt%), 20 parts by weight of xylene (purchased from Sinopec Changling Refinery, purity 98.5wt%) and 2 parts by weight of *tert*-butanol (purchased from Shanghai Xingao Chemical Reagent Co., Ltd., purity 98.5wt%) are added into 68 parts by weight of raw gasoline respectively and mixed evenly, so as to obain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 5wt%, the content of ethyl *tert*-butyl ether is 5wt%, the content of xylene is 20wt% and the content of *tert*-butanol is 2wt%. The technical indices of the obtained gasoline composition are listed in Table 8.

Comparative Example 9

[0142] A gasoline composition is obtained by the method same as Example 17, except that no *sec*-butyl acetate is added, while 10 parts by weight of ethyl *tert*-butyl ether, 20 parts by weight of xylene and 2 parts by weight of tert-butanol are added to 68 parts by weight of raw gasoline respectively and mixed evenly, so as to obtain a gasoline composition. In the obtained gasoline composition, the content of ethyl *tert*-butyl ether is 10wt%, the content of xylene is 20wt% and the content of tert-butanol is 2wt%. The technical indices of the obtained gasoline composition are listed in Table 8.

Example 18

[0143] This example is intended to describe the gasoline composition and its preparation method provided by the present invention.

[0144] The *sec*-butyl acetate and raw gasoline used in this example are same as those in Example 5.

[0145] 5 parts by weight of *sec*-butyl acetate, 1 part by weight of methyl *tert*-butyl ether (purchased from Shanghai Yuanjing Chemicals Co., Ltd., purity 98.5wt%) and 10 parts by weight of xylene (purchased from Sinopec Changling Refinery, purity 98.5wt%) are added into 84 parts by weight of raw gasoline respectively and mixed evenly, so as to obtain a gasoline composition of the present invention. In the obtained gasoline composition, the content of *sec*-butyl acetate is 5wt%, the content of methyl *tert*-butyl ether is 1wt% and the content of xylene is 10wt%. The technical indices of the obtained gasoline composition are listed in Table 8.

Comparative Example 10

[0146] A gasoline composition is obtained by the method same as Example 18, except that no *sec*-butyl acetate is added, while 6 parts by weight of methyl *tert*-butyl ether and 10 parts by weight of xylene are added into 84 parts by weight of raw gasoline respectively and mixed evenly, so as to obtain a gasoline composition. In the obtained gasoline composition, the content of methyl *tert*-butyl ether is 6wt% and the content of xylene is 10wt%. The technical indicds of the obtained gasoline composition are listed in Table 8.

Table 8

Analytical items	Test result					
	Catalyzed gasoline	*sec*-butyl acetate	Example 17	Example 18	Comparative Example 9	Comparative Example 10
Density (kg/m^3)	722.0	862.0	759.4	742.5	753.8	736.9
10vol% evaporating temperature (°C)	40.5	-	55.0	52.5	53.0	50.5

(continued)

Analytical items	Test result					
	Catalyzed gasoline	*sec*-butyl acetate	Example 17	Example 18	Comparative Example 9	Comparative Example 10
50vol% evaporating temperature (°C)	86.7	-	94.8	92.0	92.8	90.5
90vol% evaporating temperature (°C)	154.3	-	143.0	149.5	141.0	147.0
Final boiling point (°C)	191.0	-	172.3	180.5	169.8	177.5
Residue amount (vol%)	1.5	-	1.5	1.5	1.5	1.5
Full efflux (vol%)	97.5	-	97.5	97.5	97.5	97.5
Aromatic hydrocarbon (vol%)	26.5	0	38.0	32.3	38.0	32.3
Olefin (vol%)	31.9	1.2	21.8	27.0	21.8	26.8
Doctor test	pass	pass	pass	pass	pass	pass
Total sulfur (wt%)	0.016	0	-	-	-	-
MON	81.4	106	87.5	84.5	86.5	84.0
RON	90.4	118.5	98.0	94.0	97.0	93.5
Anti-knock index	85.9	112.3	92.8	89.3	91.8	88.8
Water-soluble acid or alkali	not detected	-	not detected	not detected	not detected	not detected
Vapor pressure (kPa)	68.5	4.6	48.6	60.8	49.7	62.5
Oxygen content (wt%)	0.1	27.2	2.6	1.6	2.1	1.2
Methanol content (wt%)	0.01	0	0.01	0.01	0.01	0.013
Benzene content (vol%)	0.68	0	0.46	0.6	0.46	0.6
Existent gum (mg/100mL)	3.0	0.6	2.3	2.8	2.3	3.0
Copper strip corrosion	1a	1a	1a	1a	1a	1a
Induction period (min)	560	>600	>600	>600	>600	>600

[0147] The result in Table 8 indicates that *sec*-butyl acetate may be used in combination with other additives and the gasoline composition containing *sec*-butyl acetate has a higher octane number and anti-knock index.

Claims

1. A gasoline composition, **characterized in that** the gasoline composition comprises raw gasoline and *sec*-butyl acetate, based on total amount of the gasoline composition, the *sec*-butyl acetate has a content of 1-30wt%, the raw gasoline has a content of 70-99wt%.

2. The gasoline composition according to claim 1, wherein based on total amount of the gasoline composition, the sec-butyl acetate has a content of 2-10wt%, the raw gasoline has a content of 90-98wt%.

3. The gasoline composition according to claim 1, wherein the raw gasoline comprises one or more selected from the group consisting of ether-based compounds, alcohol-based compounds and aromatic hydrocarbons, based on total amount of the gasoline composition, total amount of the ether-based compounds, alcohol-based compounds and aromatic hydrocarbons in the gasoline composition is 0.02-33wt%.

4. The gasoline composition according to claim 3, wherein the aromatic hydrocarbons are one or more selected from the group consisting of benzene, toluene, ethylbenzene, xylene, trimethylbenzene and C10 aromatic hydrocarbon, based on total amount of the gasoline composition, the aromatic hydrocarbons have a content of 0.02-33wt%.

5. The gasoline composition according to claim 3, wherein the ether-based compounds are one or more selected from the group consisting of methyl *tert*-butyl ether, ethyl *tert*-butyl ether, *tert*-amyl methyl ether and dibutyl ether, based on total amount of the gasoline composition, the ether-based compounds have a content of 0.1-15wt%.

6. The gasoline composition according to claim 3, wherein the alcohol-based compounds are one or more selected from the group consisting of methanol, ethanol, *n*-butanol, *sec*-butanol and *tert*-butanol, based on total amount of the gasoline composition, the alcohol-based compounds have a content of 0.02-10wt%.

7. A preparation method of the gasoline composition according to claim 1, **characterized in that** the method comprises a step of adding *sec*-butyl acetate into raw material gasoline, based on total amount of the gasoline composition, the *sec*-butyl acetate is added in an amount making content of the *sec*-butyl acetate in the gasoline composition in a range of 1-30wt% and content of the raw gasoline in a range of of 70-99wt%.

8. The preparation method according to claim 7, wherein based on total amount of the gasoline composition, the *sec*-butyl acetate is added in an amount making content of the *sec*-butyl acetate in the gasoline composition in a range of 2-10wt% and content of the raw gasoline in a range of 90-98wt%.

9. The preparation method according to claim 7 or 8, wherein the *sec*-butyl acetate has a purity of no lower than 80wt%.

10. The preparation method according to claim 7, wherein the method further comprises a step of adding one or more selected from the group consisting of ether-based compounds, alcohol-based compounds and aromatic hydrocarbons into the raw material gasoline, based on total amount of the gasoline composition, total amount of the ether-based compounds, alcohol-based compounds and aromatic hydrocarbons in the gasoline composition is 0.02-33wt%.

11. The preparation method according to claim 10, wherein the ether-based compounds are added in an amount making total content of the ether-based compounds in the gasoline composition in a range of of 0.1-15wt%, the alcohol-based compounds are added in an amount making total content of alcohol-based compounds in the gasoline composition in a range of 0.02-10wt%, and the aromatic hydrocarbons are added in an amount making total content of aromatic hydrocarbons in the gasoline composition in a range of 0.02-33wt%.

12. The preparation method according to claim 10 or 11, wherein the ether-based compounds are one or more selected from the group consisting of methyl *tert*-butyl ether, ethyl *tert*-butyl ether, *tert*-amyl methyl ether and dibutyl ether, the alcohol-based compounds are one or more selected from the group consisting of methanol, ethanol, *n*-butanol, *sec*-butanol and *tert*-butanol,and the aromatic hydrocarbons are one or more selected from the group consiting of benzene, toluene, ethylbenzene, xylene, trimethylbenzene and C10 aromatic hydrocarbon.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/078538

A. CLASSIFICATION OF SUBJECT MATTER

See the extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: C10L

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

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

WPI, EPODOC, STN, CNPAT, CNKI: butyl acetate, methyl-tert butyl ether, trimethylbenzene, gas, gasoline, petroleum, secbutyl acetate, ether, alcohol, arene, aromatic hydrocarbon, MTBE, ethyl tert-butyl ether, methanol, ethanol, butanol, benzene, toluene, xylene, preparative method

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 1789382 A (SHANGHAI ZHONGYOU HOLDING CO., LTD.), 21 June 2006 (21.06.2006), abstract, claims, and embodiments	1-12
X	CN 101240201 A (CHEN, Jiaxin), 13 August 2008 (13.08.2008), abstract, claims, and embodiments	1-12
X	CN 101691510 A (JINAN DEVELOPMENT ZONE XINGHUO TECHNOLOGY RESEARCH INSTITUTE), 07 April 2010 (07.04.2010), abstract, embodiments, and claims	1-12

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 November 2011 (23.11.2011)	**22 December 2011 (22.12.2011)**
Name and mailing address of the ISA/CN: State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No.: (86-10) 62019451	Authorized officer **DING, Wei** Telephone No.: (86-10) **82245588**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/078538

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 1789382 A	21.06.2006	None	
CN 101240201 A	13.08.2008	CN 101240201 B	09.06.2010
CN 101691510 A	07.04.2010	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/078538

CLASSIFICATION OF SUBJECT MATTER

C10L 1/19 (2006.01) i

C10L 10/10 (2006.01) i

C10L 10/18 (2006.01) i

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