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## SAFETY FUEL

Cecil L. Brown, Baton Rouge, La., assignor to Standard Oil Development Company, a corporation of Delaware

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9 Claims. (Cl. 44—80)

This application is a division of copending application Serial No. 244,357, filed December 7, 1938, now Patent No. 2,321,280, dated June 8, 1943.

The present invention is directed to fuels for air craft, known as safety fuels.

Safety fuels are characterized by a high flash point, a high octane number, good volatility and gum stability. For example, a good safety fuel should have a Tag closed cup flash point of 100° F. or more, an octane number of about 100, and a boiling range of about 300–400° F. It should have also the other characteristics of good aviation gasoline, such as a good gum stability and a good break down test.

The desirability of using a safety fuel has long been apparent in the aviation industry. Thus far, however, the industry has not universally adopted any standard safety fuel, primarily because there has been no available source of supply of such fuels at a suitable price.

It has hitherto been proposed to produce safety fuels by several methods such as the destructive hydrogenation of selected distillates or crudes, the extraction with sulfur dioxide of certain distillates or crudes, and the catalytic cracking under selected conditions of such extracts. The fuels produced by the first method are rather high priced due to the limited quantity of suitable raw materials. The fuels produced by the latter two methods have so low an initial octane number and so low a lead susceptibility that the amount of lead required to convert them into 100 octane fuels makes their cost well-nigh prohibitive.

I have now found that fuels having satisfactory characteristics for safety fuels such as high initial octane number, high lead susceptibility and suitable boiling range can be produced from $C_4$ iso-hydrocarbons. For example, the copolymerization of normal and isobutylene yields a heavy hydrocarbon fraction which, when hydrogenated, boils between about 300 and 385° F., has a high flash point and a high octane number.

I have found that by cutting the mixture of hydrocarbons produced by the reaction between an isoparaffin and an olefin, such as isobutane and normal or isobutylene, at about 300° F., it is possible to produce a heavy fraction having a boiling range of from about 300 to 400° F. which has a Tag closed cup flash in excess of 100° F., a high initial octane number, and a high lead susceptibility. A particularly desirable safety fuel, according to the present invention, is a blend of the last mentioned heavy fraction of alkylation product with hydrogenated tri-isobutylenes boiling between about 330 and 380° F., with the latter constituting from 10 to 50% of the blend.

The basic materials for the safety fuels of the present invention are available in large quantities and the methods by which they are converted into the desired safety fuels are not costly. For example, practically all refinery gases resulting from cracking processes of various types contain substantial percentages of isobutylene and normal butylene which can be caused to copolymerize by being contacted with sulfuric acid of a strength ranging from 60 to 75% at a temperature between about 175 and 250° F. This process is usually conducted with a view of producing dimer, and to this end it may be desirable to recycle trimer to the reaction chamber. As the result of the present invention, this process can be carried out with a view of producing the highest yield per pass of high boiling hydrocarbons, whereby the efficiency of the method is increased.

There are large reservoirs of isobutane which can be utilized as sources of raw material for the second embodiment of the present invention. The reaction between isobutane and the olefins of refinery gases proceeds with ease at normal room temperatures in the presence of concentrated sulfuric acid. This reaction, which yields a product containing $C_5+$ hydrocarbons, can be made to yield substantial amounts of a product boiling within the safety fuel range by recycling $C_5$–$C_8$ hydrocarbons to the reaction zone.

The fuels of the present invention do not per se have an octane number of 100. The co-polymer of isobutylene and normal butylenes, when hydrogenated, has an octane number of about 90 which can be brought to 99.5 with 3 cc. of tetraethyl lead per gallon. Likewise, the high boiling alkylation fraction, especially when blended with about 40% of hydrogenated triisobutylene, has a clear octane number of about 90 which can be raised to 100 with 3 cc. of tetraethyl lead per gallon.

The safety fuel of the present invention is preferably composed entirely of the reaction product of an iso-$C_4$ hydrocarbon with a different $C_4$ hydrocarbon. It may be mentioned, however, that, when the fuel is an alkylation product, it may be produced from isopentane or isohexane as well as from isobutane. Likewise, olefins other than the butylenes may be employed. In any case, the fuel, as previously mentioned, may contain sub-

stantial quantities of hydrogenated triisobutylene. Other suitable blending agents are alkylated aromatics boiling between 300 and 400° F. Typical examples of such alkylated aromatics are ethyl benzene, propyl benzene, isopropyl benzene, methyl benzene, *o*, *m*, *p*, trimethyl benzene, 1, 2, 3, trimethyl benzene 1, 2, 4, trimethyl benzene, 1, 3, 5, secondary butyl benzene, isobutyl benzene, tertiary butyl benzene, and methyl isopropyl benzene, *p*.

Alternatively, a fraction boiling between 300 and 400° F. of the product resulting from the alkylation of aromatics with olefins may be employed.

The characteristics of typical examples of aviation safety fuel according to the present invention are given in the following table. Fuel A of this table was prepared by reacting isobutylene and normal butylene in the presence of sulfuric acid of a strength of about 70% at a temperature of 170° F., recovering from the product a fraction boiling above 300° F. and hydrogenating this fraction by contacting it with a catalyst composed of $MoO_3$, ZnO and MgO at a temperature of 500–600° F. and under a pressure of 3000 pounds per square inch in the presence of a large excess of hydrogen.

Fuel B was prepared by reacting isobutane and the iso- and normal butylene in $C_4$ refinery cut in the presence of sulfuric acid having a strength of 98% at a temperature of 70° F. and under a pressure sufficient to maintain the reactants in the liquid state and recovering from the product a fraction having the boiling range shown in the table.

Fuel C was prepared by blending with fuel B hydrogenated triisobutylene boiling between 330 and 358° F., the latter constituting 40% of the blend.

| | Fuel A | Fuel B | Fuel C |
|---|---|---|---|
| A. P. I. gravity | 52.7 | 55.8 | 55.8 |
| Color Saybolt | +19 | +26 | +27 |
| Aniline point °F. | | 182 | 189 |
| Sulfur percent | 0.01 | 0.02 | 0.008 |
| Doctor | Passes | Passes | Passes |
| Corrosion, cu. dish | Passes | Passes | Passes |
| Gum, cu. dish mgs. | | 3.6 | 3.8 |
| Acid heat °F. | 2 | 1 | 2 |
| Bromine No. | 3 | 1 | 2 |
| Flash, Tag closed cup | 112 | 103 | 104 |
| Reid vapor pressure | Below 1# | Below 1# | Below 1# |
| Army octane number | 89.4 | 77.0 | 85.3 |
| Army octane number+3.0 cc. TEL. | 99.5 | 96.4 | 100 |
| Initial °F. | 304 | 323 | 328 |
| 5% | 319 | 336 | 336 |
| 10% | 324 | 341 | 340 |
| 30% | 336 | 351 | 347 |
| 50% | 345 | 357 | 352 |
| 70% | 352 | 363 | 355 |
| 90% | 362 | 373 | 364 |
| Final °F. | 384 | 393 | 385 |
| Recovery percent | 98.0 | 98.0 | 98.0 |
| Residue do | 1.0 | 1.0 | 1.0 |

The nature and objects of the present invention having thus been described, what is claimed as new and useful and is desired to be secured by Letters Patent is:

1. A safety fuel boiling substantially completely between about 300° F. and about 400° F., having a flash point of at least 100° F. by the closed cup method, composed predominantly of a mixture of paraffinic reaction products of an isoparaffin and an olefin and also containing compounds formed by hydrogenating the normally liquid condensation product of $C_4$ olefins said product boiling within the above-stated range, said mixture containing also sufficient anti-knock agent to raise its octane number to 100.

2. A safety fuel boiling substantially completely between about 300° F. and 400° F., having a flash point of at least 100° F. by the closed cup method, composed predominantly of a mixture of paraffinic reaction products of an isoparaffin and an olefin and compounds formed by hydrogenating the condensation product of normal and isobutylenes said product boiling within the above-stated range and said mixture containing sufficient anti-knock agent to raise its octane number to about 100.

3. A safety fuel boiling substantially completely between about 300° F. and 400° F., having a flash point of at least 100° F. by the closed cup method, composed of a mixture of hydrogenated tri-butylenes said product boiling within the above-stated range and paraffinic reaction products of an isoparaffin and an olefin, and containing sufficient anti-knock agent to bring its octane number to about 100.

4. A safety fuel according to claim 3 in which hydrogenated tri-isobutylenes boiling between about 330° F. and about 380° F. constitute from about 10 to about 50% of the mixture.

5. A safety fuel boiling substantially completely between about 300° F. and about 400° F., having a flash point of at least 100° F. by the closed cup method, composed predominantly of a mixture of paraffinic reaction products of isopentane and an olefin and compounds formed by hydrogenating the normally liquid condensation products of $C_4$ olefins said products boiling within the above-stated range, said mixture containing sufficient anti-knock agent to raise its octane number to about 100.

6. A safety fuel boiling substantially completely between about 300° F. and about 400° F., having a flash point of at least 100° F. by the closed cup method, composed predominantly of a mixture of paraffinic reaction products of isopentane and an olefin and compounds formed by hydrogenating the normally liquid condensation products of isobutylene said products boiling within the above-stated range, said mixture containing sufficient anti-knock agent to raise its octane number to about 100.

7. A safety fuel boiling substantially completely between about 300° F. and about 400° F., having a flash point of at least 100° F. by the closed cup method, composed predominantly of a mixture of paraffinic reaction products of isopentane and an olefin and compounds formed by hydrogenating triisobutylene, said mixture containing sufficient anti-knock agent to raise its octane number to about 100.

8. A safety fuel boiling substantially completely between about 300 and 400° F., having a flash point of at least 100° F. by the closed cup method, composed of hydrogenated triisobutylene and the paraffinic compounds formed by the reaction between isobutane and a $C_4$ olefin, and containing sufficient anti-knock agent to bring its octane number to about 100.

9. A safety fuel boiling substantially completely between about 300° and 400° F., having a flash point of at least 100° F. by the closed cup method, composed of hydrogenated triisobutylene and paraffinic compounds formed by the reaction between isobutane and isobutylene, and containing sufficient antiknock agent to bring its octane number to about 100.

CECIL L. BROWN.