Patented July 2, 1940

2,206,594

UNITED STATES PATENT OFFICE

2,206,594

DIESEL FUEL

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No Drawing. Application November 8, 1938, Serial No. 239,506

10 Claims. (Cl. 44—9)

This invention has to do in a general way with fuels for internal combustion engines of the Diesel or compression ignition type and is more particularly concerned with the improvement of such fuels by the admixture therewith of a characterizing ingredient. In an internal combustion engine operating on the Diesel cycle it is important to the attainment of maximum efficiency that the delay period between the injection of the fuel and its ignition in the cylinder be short. Improperly delayed ignition gives rise to the phenomenon known as "knocking" because of improper coordination between the combustion and cylinder conditions. By decreasing the ignition delay period of a Diesel fuel it is possible to lower the compression pressure at which ignition of the fuel mixture takes place, thus insuring spontaneous ignition without combustion shock. This increases the ease of starting and the smoothness with which combustion takes place, and in addition it permits less weight or mass in the engine design, which makes for lower cost per unit of power output. It will be seen, therefore, that enhanced speed of ignition is a characteristic highly desirable in fuels for use in Diesel engines.

It has been found that the ignition quality of a Diesel or compression ignition fuel can be improved by the addition thereto of small amounts of certain compounds which act as ignition accelerators. This offers a means for improving the better grades of Diesel fuels and also permits widening the range of available fuels by raising the ignition quality of the low grade fuels.

The present invention is directed to Diesel type fuels which have been improved in ignition quality by the addition of novel compounds which promote rapidity of combustion and so give the desired control over the fuel's combustion characteristics. More specifically our invention has as its object the provision of an improved method of accelerating the ignition of liquid hydrocarbon fuels in compression ignition engines which is characterized by the admixture with the fuel of a reaction product which we will hereinafter refer to as a material predominantly comprised of hydrogen persulfides.

As a material predominantly comprised of hydrogen persulfides our invention comprehends the crude reaction products to be hereinafter described, which are comprised of hydrogen persulfides containing sulfur in solution; also those materials obtained as distillates from this crude reaction product, which are considered to be a mixture of hydrogen persulfides and in addition our invention contemplates materials which are obtained as the residue from such distillation, such residue being a mixture of hydrogen persulfides and sulfur.

Materials of the type just referred to above may be conveniently prepared by the method described by Walton and Parsons (J. Am. Chem. Soc., 1921, 43, 2539). This procedure involves the steps of preparing a solution of sodium persulfides by dissolving and digesting elementary sulfur in a sodium sulfide solution and then acidifying this solution to liberate the hydrogen persulfides. The hydrogen persulfide mixture obtained from this reaction may be separated from the aqueous solution, and such crude mixture can be used as an improving agent for Diesel fuels. This crude persulfide mixture may be distilled under vacuum to obtain what we may term purified hydrogen persulfides, which also are effective improving agents for Diesel fuels, and the residue from such distillation may also be employed as an improving agent.

Walton and Parsons report that the crude product of the reaction described above is believed to be a solution of sulfur in equilibrium with various sulfides of hydrogen and not a definite compound and for this reason we have chosen to define such product herein in general chemical terms or by its method of preparation rather than attempting to definitely identify the various constituent compounds.

The details in one illustrative procedure which may be followed in preparing the ignition accelerators for Diesel fuel contemplated by this invention will be best understood from the following specific example:

The sodium sulfide-sulfur solution was prepared by dissolving 667 grams of crystalline sodium sulfide and 100 grams of flowers of sulfur in 267 cc. of distilled water. This solution was prepared in a stoppered flask equipped with a Bunsen valve by heating on a water bath for three hours. The contents of the flask were then slowly added with constant stirring below the surface of two liters of concentrated hydrochloric acid, which was maintained at a temperature between —4° and —10° C. The crude hydrogen persulfide mixture thus formed was at first largely present as an emulsion but settled to the bottom of the container over night. This crude liquid was then separated, washed several times with water, and dried by allowing it to stand in contact with phosphorus pentoxide for two days. The phosphorus pentoxide was removed by filtration and a portion of the crude

hydrogen persulfide filtrate, hereinafter referred to as "product A," was used in preparing a Diesel fuel blend.

The product herein referred to as the purified hydrogen persulfides was obtained by vacuum-distilling the crude product described above at a liquid temperature of 120° C. and under pressure of 5 mm. The distillate was collected in two portions, as hydrogen trisulfide and hydrogen disulfide, but these two portions were combined and tested as the product hereinafter referred to as "product B."

The residue left after this distillation, which was comprised of a mixture of the persulfides and elementary sulfur, was also tested as an ignition accelerator for Diesel fuel and is hereinafter identified as "product C."

To demonstrate the effectiveness of the products contemplated by this invention as ignition accelerators for Diesel fuels we have prepared fuel blends containing the products A, B, and C described above and have determined the ignition quality of such blended fuel by comparison with a standard reference fuel in a converted C. F. R. engine, using the ignition delay method. The results obtained are expressed as "Cetane numbers," which represent the percent by volume of cetane in a blend of cetane and alpha methyl naphthalene having the same combustion characteristics as the sample under test (see Proc. Am. Soc. Testing Materials, vol. 36, I p. 416, (1936)). An increase in cetane number indicates an improvement in the combustion characteristics of the fuel.

The results of these tests, which are indicated in the table below, were obtained with blends prepared from a Diesel fuel oil having the following characteristics:

A. P. I. gravity	40.1
Pour point	—20° F.
Flash, Pensky Marten	158° F.
Color	0.8 Lovibond
Aniline point	154.5° F.
Distillation:	
Initial	358° F.
10%	414° F.
90%	573° F.
End point	619° F.
Per cent sulfur	0.10
Cetane number	56

The amount of the persulfide product (A, B or C) in the blend in each case is indicated by the percentage of sulfur in the blended oil.

Table I

Material blended with 56 cetane No. fuel	Percent S in blend	Cetane No. of blend	Increase in cetane No.
Product A	0.57	59.5	3.5
Product B	0.47	61	5
Product C	1.02	62	6

It will be apparent from the foregoing table that all of the products contemplated by this invention, which we have broadly characterized as being predominantly comprised of hydrogen persulfides, are effective when admixed with a fuel oil refined for use in a compression ignition engine to materially improve the ignition quality of the fuel.

It is to be understood that the terms "Diesel fuel," "Diesel type fuel," "hydrocarbon fuel oil," etc., as used herein are inclusive of any and all types of hydrocarbon products intended for use in any engine operating according to the Diesel cycle.

We claim:

1. An improved Diesel fuel comprising: a hydrocarbon fuel oil and in admixture therewith a minor proportion of hydrogen persulfides and elementary sulfur in an amount sufficient to decrease the ignition delay period of the fuel.

2. An improved Diesel fuel comprising: a hydrocarbon fuel oil and in admixture therewith a minor proportion of hydrogen persulfides in an amount sufficient to decrease the ignition delay period of the fuel.

3. An improved Diesel fuel comprising: a hydrocarbon fuel oil and in admixture therewith a minor proportion of a crude hydrogen persulfide-sulfur mixture obtained by digesting a water solution of sodium sulfide and elementary sulfur at an elevated temperature; acidifying the reaction mixture with hydrochloric acid to form the hydrogen persulfide-sulfur mixture; and separating said mixture from the aqueous solution, said mixture being present in the oil in an amount sufficient to decrease the ignition delay period of the fuel.

4. An improved Diesel fuel comprising: a hydrocarbon fuel oil and in admixture therewith a minor proportion of purified hydrogen persulfides obtained by digesting a water solution of sodium sulfide and elementary sulfur at an elevated temperature, acidifying the reaction mixture with hydrochloric acid to form crude hydrogen persulfides, separating the crude hydrogen persulfides from the aqueous solution, washing and drying the crude hydrogen persulfides, and distilling the crude hydrogen persulfides under vacuum at a liquid temperature in the neighborhood of 120° C. to obtain the purified hydrogen persulfides, said purified hydrogen persulfides being present in the oil in sufficient amount to decrease the ignition delay period of the fuel.

5. An improved Diesel fuel comprising: a hydrocarbon fuel oil and in admixture therewith a minor proportion of the residue obtained from the distillation under vacuum at a liquid temperature in the neighborhood of 120° C. of the reaction product obtained by digesting a water solution of sodium sulfide and elementary sulfur at an elevated temperature, acidifying the product thus obtained with hydrochloric acid and then separating the aqueous solution from the crude product to be distilled, said residue being present in the oil in an amount sufficient to decrease the ignition delay period of the fuel.

6. An improved Diesel fuel comprising: a hydrocarbon fuel oil and in admixture therewith a minor proportion of a crude hydrogen persulfide sulfur mixture obtained by digesting a water solution of about 6.7 parts of sodium sulfide and about one part of elementary sulfur at an elevated temperature; acidifying the reaction mixture with hydrochloric acid to form the hydrogen persulfide-sulfur mixture; and separating said mixture from the aqueous solution, said mixture being present in the oil in an amount sufficient to decrease the ignition delay period of the fuel.

7. An improved Diesel fuel comprising: a hydrocarbon fuel oil and in admixture therewith a minor proportion of purified hydrogen persulfides obtained by digesting a water solution of about 6.7 parts of sodium sulfide and about one part of elementary sulfur at elevated temperature, acidifying the reaction mixture with hydrochloric acid to form crude hydrogen persulfides, separating the crude hydrogen persulfide

from the aqueous solution; washing and drying the crude hydrogen persulfides; and distilling the crude hydrogen persulfides under vacuum at a liquid temperature in the neighborhood of 120° C. to obtain the purified hydrogen persulfides, said purified hydrogen persulfides being present in the oil in sufficient amount to decrease the ignition delay period of the fuel.

8. The method of accelerating the ignition of liquid fuels for internal combustion engines of the type wherein ignition of the fuel is spontaneously effected by injection into the compressed air in the engine cylinder which comprises admixing with the fuel prior to ignition a minor proportion of a material predominantly comprised of hydrogen persulfides.

9. The method of accelerating the ignition of liquid fuels for internal combustion engines of the type wherein ignition of the fuel is spontaneously effected by injection into the compressed air in the engine cylinder which comprises admixing with the fuel prior to ignition a minor proportion of a material comprised of hydrogen persulfides and sulfur.

10. The method of accelerating the ignition of liquid fuels for internal combustion engines of the type wherein ignition of the fuel is spontaneously effected by injection into the compressed air in the engine cylinder which comprises admixing with the fuel prior to ignition a minor proportion of hydrogen persulfides.

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