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Carroway (43) **Pub. Date: Feb. 22, 2007**(54) **PROCESS FOR CONVERTING TALLOW TO
DIESEL FUEL**(52) **U.S. Cl. 44/393**(76) **Inventor: William Carroway, Cashiers, NC (US)**(57) **ABSTRACT**

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A process for thermally cracking virgin or waste animal oils (tallow) into a diesel fuel product is provided. The thermal cracking process uses low cracking temperatures from 625 to 725° F. with ambient pressure and no catalyst to generate a column distilled fraction of diesel fuel mixed with light ends, the light ends being flashed off to produce a high quality #2 diesel fuel suitable for road use. The oils to be distilled are exposed to a heat exchanger with a skin temperature of 1750° F. generated by hot air produced by a thermal oxidizer. This results in the processed product going from a liquid to a liquid/gas during the pump around residence time of 3 to 5 seconds before moving up a distillation column as a gas to the desired finished product.

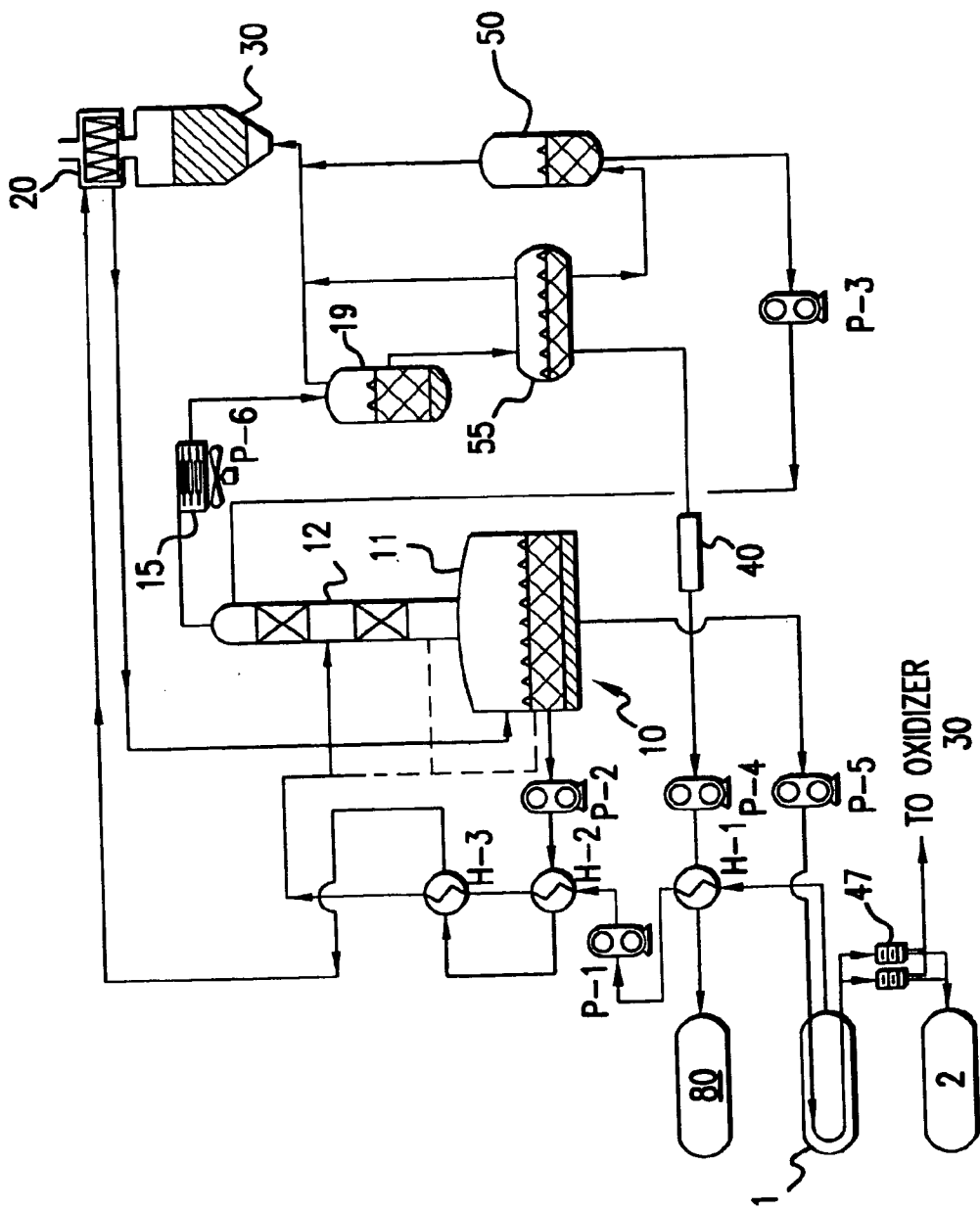


FIG.1

PROCESS FOR CONVERTING TALLOW TO DIESEL FUEL

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates generally to the field of fuel for internal combustion engines, and specifically concerns a process for converting virgin or used animal fats or oils, called tallow, to a useable fuel source.

[0003] 2. Description of the Prior Art

[0004] Edible oils are essential for the human diet and therefore their use for other purposes has not received much attention. During and after World War II several studies on the pyrolysis of vegetable oils were carried out using the resulting products as fuel. In the late 1970's, Mobil researchers showed that a variety of biomass substrates could be catalytically converted to liquid aromatic hydrocarbons and olefins using a shape selective ZSM-5 zeolite catalyst. One of the feedstocks tried was corn oil, an unsaturated triglyceride vegetable oil. The hydrocarbon end products from this oil represent clean premium fuels: LPG, high octane gasoline with a high aromatic content and a light distillate fraction.

[0005] Confirmatory studies and improved analysis of the fuel components were conducted and published in 1983 ("Pyrolysis of Tropical Vegetable Oils", J. W. Alencar et al., J. Agric. Food Chem., 31, 1266-1270). It was found that the pyrolysis reaction evolved gas due to decarboxylation reactions. The removal of the carboxyl groups from the fatty acids left a desirable mixture of n-alkanes and 1-alkenes as the major products. Unsaturated fatty acids (containing at least one carbon-carbon double bond) seemed to generate more volatile molecules than the saturated equivalents. As a result, it was possible to make an association between the major saturated fatty acids present in the original oil and the chief saturated hydrocarbon in the pyrolysed product. Pyrolysis of triglycerides made up of oleic acids not only produced straight chain hydrocarbons but also cycloparaffins and cycloolefins in small amounts. The absence of oxygenated compounds amongst the volatile hydrocarbons suggested that the elimination of carbon dioxide CO₂ and CH₂=CO were the dominant cracking reactions of triglycerides and fatty acids in the absence of a catalyst. The formation of alkane and alkene molecules was reported to be consistent with the generation of the radicals RCOO— and RCH₂CO— from the triglyceride molecule. These radicals would preferentially react with the double bond in the unsaturated fatty acids to cleave the hydrocarbon chain at that point and thereby giving rise to the smaller volatile hydrocarbon molecules. Notably, palm oil which is composed mainly of saturated C16 fatty acids (palmitic acid) gave the highest percentage of heavier hydrocarbons (C15, C14 and C13) fractions that contribute significantly to the make-up of diesel fuel. Overall, 40% of the product from cracked vegetable oil was in the diesel molecular range (C12-C18). With calcium oxide as a catalyst, the main products were long chain methyl ketones. Research recently conducted at the University of Saskatchewan has shown that canola oil can also be converted, with yields in excess of 98 wt. %, using the same catalyst as the above-mentioned Mobil researchers, where 70-75% of the converted product is a high octane gasoline. The process used was Fluid

Catalytic Cracking (FCC). It was therefore evident that animal fats (tallow) that are comprised mainly of saturated fatty acids with a higher proportion of the longer-chained fatty acids could theoretically produce a diesel fuel with the proper characteristics for automotive diesel.

[0006] The composition of tallow is provided in Table 1.

TABLE 1

A typical distribution of Fatty Acids in tallow is as follows;

2% Myristic Acid (C ₁₄ - saturated), chemical formula C ₁₃ H ₂₇ COOH
32.5% Palmitic Acid (C ₁₆ - saturated), chemical formula C ₁₅ H ₃₁ COOH
14.5% Stearic Acid (C ₁₈ - saturated), chemical formula C ₁₇ H ₃₅ COOH
48.3% Oleic Acid (C ₁₈ - one double-bond, at C ₉), chemical formula C ₁₇ H ₃₅ COOH
2.7% Linoleic Acid (C ₁₈ - two double-bonds, at C ₆ and C ₉), chemical formula C ₁₇ H ₃₃ COOH
Total saturated fats 47%, Total C18 fatty acids 65.5%.

[0007] Currently, the market for virgin and used tallow is large in the United States but the European Union (EU) has seen fit to designate tallow as a possible specified risk material (SRM) and thus it is a waste product in light of concerns over bovine spongiform encephalitis or "Mad Cow Disease". SRM is tallow derived from the rendering of infected carcasses or nerve tissue. Usually tallow is employed as human and animal feed additives in addition to its use as a cosmetic ingredient mainly for soap production. But because of the EU decision to treat tallow as an SRM, the EU will develop a large requirement for the disposal of this material. Yellow grease is often comprised of low-grade inedible tallow and used vegetable oil. Used vegetable oil that was employed as an animal feed is also to be designated as an SRM by the EU adding further to the disposal of these hydrocarbon sources. Tallow can be burned to generate heat and, often, low grades of tallow are utilized for this purpose especially by meat renderers themselves. Used vegetable oil can also be burned to generate heat or electricity but this application for this heavy fuel is being prevented due to air emission controls.

[0008] To recycle these resources several groups have developed improved methods to convert the waste natural oils into a renewable fuel sources, namely biodiesel. Biodiesel has become synonymous with the chemical conversion of tallow and used or virgin vegetable oils into an automotive fuel. The natural oils (triglycerides) are converted, using a base catalyst and alcohol, into esters that have the advantage of almost no toxicity and potential as a renewable fuel source. In Europe, large quantities of fatty acid methyl esters are produced by reacting rapeseed oil with methanol in the presence of a strong base. The process is simple but cumbersome and relatively expensive though no pollution is created through this process. The chemical process has been optimized for the production of esters from vegetable oils but such esters can be produced using tallow as the raw material. However, the resulting fuels are not identical and tallow derived biodiesel has very limited practical use that results from its poor cold weather performance.

[0009] Biodiesel fuel has a number of advantages over mineral diesel aside from coming from a renewable resource. The lack of environmental toxicity is helpful in the event of an accidental spill and the material is far less flammable making it easier to handle. When the fuel is

burning in an internal combustion engine the resulting pollution is significantly reduced compared to mineral diesel. Where biodiesel loses out to mineral diesel aside from the more expensive production process, is the poorer cold flow characteristics requiring that biodiesel be used solely in warmer climates (B100) or mixed with mineral diesel usually to a ratio of 20:80 (known in the industry as B20). Biodiesel derived from tallow has much poorer cold weather performance than the vegetable derived product, being almost solid at temperatures above freezing. The performance of tallow biodiesel is so poor that the maximum blend ratio with mineral diesel is 10:90. Accordingly, biodiesel will never substitute for mineral diesel in climates that have winter temperatures drop below freezing (32° F. or 0° C.).

[0010] To overcome this limiting aspect in biodiesel, others have proposed cracking the esters to produce a fuel with better cold flow properties. See Bradin, U.S. Pat. No. 5,578,090. The resulting fuel additive composition is thermally cracked under conditions of increased temperature and/or pressure in the presence of a Lewis acid catalyst. The biodiesel fuel additive composition is heated to a temperature of between approximately 100 and 500° F., and contacted with a Lewis acid catalyst, to thermally crack the hydrocarbon chains in the fatty acid alkyl esters. The Lewis acid can be any Lewis acid that is effective for cracking hydrocarbons, including but not limited to zeolites, clay montmorillite, aluminum chloride, aluminum bromide, ferrous chloride and ferrous bromide. In another embodiment, Bradin claims that the biodiesel fuel additive composition can be pyrolyzed resulting in a lower viscosity.

[0011] The economic costs of waste vegetable oil and tallow as a raw material have prevented the adoption of these technologies because the resulting fuel is not competitive with mineral diesel. However, in Europe with the implementation of new regulations governing the use of waste natural oils there has been renewed vigor in developing new fuel technologies and disposal methods that are environmentally friendly.

[0012] Equipment used in the present invention is substantially similar to that used in Wansbrough et al., U.S. Pat. No. 5,885,999. U.S. Patent numbers cited on that patent are U.S. Pat. No. 1,546,055 July, 1925 Wilson et al.; U.S. Pat. No. 3,717,569 February, 1973 McAllister et al.; U.S. Pat. No. 3,923,643 December, 1975 Lewis et al.; U.S. Pat. No. 3,954,602 May., 1976 Troesch et al.; U.S. Pat. No. 4,033,859 July, 1977 Davidson et al.; U.S. Pat. No. 4,071,438 January, 1978 O'Blasny; U.S. Pat. No. 4,101,414 July, 1978 Kim et al.; U.S. Pat. No. 4,190,520 February, 1980 Gewartowski; U.S. Pat. No. 4,233,140 November, 1980 Antonelli et al.; U.S. Pat. No. 4,292,140 September, 1981 Kawasaki et al.; U.S. Pat. No. 4,381,992 May., 1983 Wood et al.; U.S. Pat. No. 4,512,878 April, 1985 Reid et al.; U.S. Pat. No. 4,666,587 May., 1987 Martin; U.S. Pat. No. 5,049,258 September, 1991 Keim et al.; U.S. Pat. No. 5,143,597 September, 1992 Sparks et al.; U.S. Pat. No. 5,248,410 September, 1993 Clausen et al.; U.S. Pat. No. 5,271,808 December, 1993 Shurtleff; and U.S. Pat. No. 5,316,743 May., 1994 LeBlanc et al. Patents relating to vegetable oil are U.S. Pat. No. 4,992,605 February 1991 Craig et al.; and the U.S. Pat. No. 5,578,090 patent issued in November 1996 to Bradin as discussed above.

SUMMARY OF THE INVENTION

[0013] Bearing in mind the foregoing, it is a principal object of the present invention to provide a process for converting animal fats or oils known as tallow into a diesel fuel product.

[0014] It is another object of the present invention to provide a process for the low temperature, catalyst-free, ambient pressure cracking of tallow into a diesel product.

[0015] It is further object of the present invention to provide a process where the conversion of tallow to a diesel fuel product complies with environmental regulations.

[0016] Other objects and advantages will become apparent to those skilled in the art upon reference to the following descriptions and the appended drawings.

[0017] In accordance with a principal aspect of the invention there is provided a process including providing a cracking apparatus, the apparatus comprising a cracking vessel, the vessel in communication with a heating source for heating the tallow, a distillation column in communication with the vessel, and a condenser in communication with the distillation column; supplying the cracking vessel with a source of tallow; heating the tallow to a cracking temperature; cracking the tallow to a mixture of lighter molecular weight compounds; separating the lighter molecular weight compounds into a first mixture of a small fraction of volatile light ends and a second mixture of diesel fuel; and collecting the second mixture of diesel fuel. The oils to be distilled are exposed to a heat exchanger with a skin temperature of 1750° F. generated by hot air produced by a thermal oxidizer. This results in the processed product going from a liquid to a liquid/gas during the pump around residence time of 3 to 5 seconds before moving up a distillation column as a gas to the desired finished product.

BRIEF DESCRIPTION OF THE DRAWING

[0018] Various other objects, advantages, and features of the invention will become apparent to those skilled in the art from the following discussion taken in conjunction with the following drawing, in which:

[0019] FIG. 1 is a schematic of the inventive process and apparatus used in the process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention which may be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed structure. Reference is now made to the drawing.

[0021] In accordance with this invention, it has been found that waste tallow and vegetable oil can be cracked under low temperature, low severity conditions to yield #2 grade diesel fuel. The equipment used in this process was developed originally to recycle used oil because the reaction occurred at much lower temperatures than was conventionally

thought to be possible and permitted the continuous flow processing of waste oil to a #2 grade diesel fuel without coking or fouling of the cracking apparatus. U.S. Pat. No. 5,885,999 was granted on the waste oil conversion process and is incorporated herein by reference in its entirety. A literature search revealed that cracking of natural vegetable oils could be achieved at similarly low temperatures.

[0022] The system and its operation is schematically shown in the process flow diagram of FIG. 1. The feedstock is comprised of tallow, and possibly other components such as used vegetable cooking oil and waste mineral oil. It is pre-heated first, preferably to 160° F., while in the holding tank 1. Preheating is accomplished by the passage through tank 1 of a heated #3 fuel oil product stream on its way to storage tank 2, or initially by steam generated by the system. By exchanging heat from the exiting #3 stream to the feedstock stream, the overall energy requirements of the system are greatly reduced. After preheating in tank 1, the feedstock is further heated by passing through a bank of three heat exchangers (H-1, H-2, H-3), until it reaches a temperature of about 675° F. Pump P-1 controls the rate of feed into the system, preferably at 5 gallons per minute with the present equipment. Production process rate depends, of course, on the capacity of the equipment acquired for use in the production process. Equipment that is currently available in the marketplace varies from 1,500 to 20,000 gallons per [time unit].

[0023] The pre-heated tallow feedstock is fed to a reaction and distillation assembly 10 comprising a cracking vessel (still pot) 11 and a distillation column 12. The cracking vessel 11 can vary in size and volume, and typically has an operating or cracking temperature of between about 625-700° F., preferably 675° F. as stated above. That temperature is maintained by a heat recovery unit 20 which is preferably powered by a thermal oxidizer 30.

[0024] The first cut is controlled by raising the temperature from the 160° F. liquid level to 225° F., removing the water or converting the water in the tallow to steam to preheat the tallow, then moving the steam through the thermal oxidizer 30 at 1750° F. to destroy anything in the steam stream. With the tallow stream free of water, its temperature is raised from 225° F. to 335° F. very quickly. In less than 2 seconds all gasses having a boiling point less than 335° F. are distilled off the remaining liquid stream of tallow. At this point, with the tallow free of both water and gasses, its high boiling point is below the top of the distillation curve, 513° F., and greater than 333° F., the lower point of the distillation curve. The flash point of the resulting fuel is now established with the water and gasses removed.

[0025] Although the cracking temperature can be raised to give a higher cracking rate, doing so undesirably increases the light end production. It is important to operate at as low a cracking temperature as possible to minimize light end production and avoid coking problems. While it is difficult to analyze cracking reactions, it has been found that it is possible to carry out the thermal cracking such that only a small percentage of light ends are being produced relative to the desired #2 diesel fuel product. Therefore, it is inferred that under the mild conditions employed, cracking products which constitute #2 diesel fuel product can be economically obtained.

[0026] A portion of the feedstock, preferably 10%, is extracted from the vessel 11 by pump P-2 and circulated

through a recirculating loop containing heat recovery unit 20. This heats the extracted feedstock to 700° F. producing a mixed vapor/liquid product. That mixed vapor/liquid product is then returned to the vessel 11 to maintain the vessel 11 at the proper process temperature of 675° F., the cut point for the top of the distillation curve for #2 diesel. The reaction in cracking vessel 11 produces some #3 product that can be extracted from vessel 11. This is done from the bottom of the vessel 11 with the rate of flow being controlled by pump P-5. It is this product #3 at elevated temperature that is used to preheat the feedstock in tank 1 enroute to storage in tank 2.

[0027] The distillation column 12 is an insulated cylinder that is preferably 14 feet in height with interior diameters of 10, 18, or 24 inches depending upon the model. The column 12 is filled with standard packing material known as nutter rings. With proper temperature control, all of the lower molecular weight material fractions whose boiling point is that of #2 diesel or less, e.g., #2 diesel, light ends, (which may include up to 200 separate components) and volatile products leave the top of the column 12 as vapors. Gases leaving the top of the column 12 pass through an air-cooled tube-type condenser 15, where the temperature is reduced by approximately 350° F. to a temperature of around 250° F., collecting mostly as liquid in the light ends flash vessel 19.

[0028] It has been found that coke formation, a common problem in petroleum cracking, is not occurring on the cracking equipment used in the present process. While coke formation is a poorly understood phenomena, it is believed that the low temperatures employed to crack the tallow are sufficiently mild that-coking is avoided.

[0029] The flash vessel 19 is fitted with two electric band heaters (not shown). Their use lowers the flash point of the product and flashes off the light ends including a light naphtha product and any water vapor. The light ends and light naphtha product are then used as fuel input to the thermal oxidizer 30. Alternatively, the #2 diesel fuel can be reheated and passed through another flash pot or a vapor separator where the more volatile light ends are separated and collected. The remaining liquid, #2 diesel fuel, is transferred to the product tank 55.

[0030] Reflux has been determined not to be needed in the present process. But the equipment shown in FIG. 1 includes conventional reflux capability because it is contemplated that the equipment will be used to additionally process waste oil as taught by U.S. Pat. No. 5,885,999 in a combined stream when the tallow is heated to a liquid. The reflux capability is needed for the waste oil application, not the tallow application. The reflux capability includes a reflux drum 50 which can be used to keep the temperature at the top of distillation column 12 somewhat cooler than that of the vessel 11. The rate of reflux, from the reflux drum 50 to the column 12, is controlled by pump P-3. This rate can be quite important. In some processes, the vapor liquid contact between reflux and hot vapors helps the cracking reaction proceed. The reflux is fed into the distillation column 12 at a location 18 inches below the top of the column. A distribution plate (not shown) which is present in the column helps distribute the reflux evenly over the column. However, since the reflux requires energy to bring the reflux back up to temperature, the goal is to provide only sufficient reflux to maximize the desired products. An excessive amount of reflux lowers the profits of the overall operating system.

[0031] The thermal oxidizer 30 takes the place of the usual reboiler. The recirculation loop between vessel 11 and heat recovery unit 20 includes two (H2, H3) of the three heat exchangers present. Accordingly, heat from the recirculation loop also pre-heats the feedstock because the other heat exchanger, H-1, exchanges heat from the #2 diesel final product line to the incoming feedstock. The rate of recirculation through this recirculation loop is controlled by pump P-4 and the amount of heat added is a function of the fuel air flow rate to the thermal oxidizer 30. The fuel/air mixture contains the light ends and some reflux. Any vapors from product tank 55 or reflux drum 50 are added to the light ends which are burned off in flash vessel 19 as fuel input to the thermal oxidizer 30. The thermal oxidizer 30 is pre-heated at start-up, and operates at temperatures of about 1750° F. It provides for thorough mixing of oxygen and fuel. The vapor mixture heats up to its oxidation temperature, where it completely oxidizes. Because the thermal oxidizer 30 inhibits flame propagation, oxidation and release of heat occur in a flameless process. The heat produced by the oxidizer is used to raise the temperature of the pre-heated feedstock to its final reaction temperature of 675° F. through the heat recovery unit 20. While a slight inherent pressure, usually 0.1 psi, may exist at the bottom of column 12 by the cracking reactions, this is still within what one skilled in the art would call atmospheric distillation.

[0032] Thermal oxidizer technology offers a number of important state of the art technological advantages as well as environmental and regulatory advantages. For example, the oxidation process converts hydrocarbons to water and carbon dioxide with a destruction/removal efficiency (DRE) of at least 99.99%. By contrast, other systems have 99% DRE. This 0.99% difference represents a release of 100 times more volatile organic compounds (VOC's) into the atmosphere. Depending upon applicable law, the levels of efficiency achieved with flameless operation may exempt the system from boiler permit requirements and may qualify it for minor source exemptions. Furthermore, another advantage of the thermal oxidizer 30 is the near-100% oxidation of input fuels. This increases the amount of heat available for use in the process, reducing the amount of required fuel supplement and improving final product yield. The thermal oxidizer is also much safer than prior art alternatives. It is flameless, with anti-flashback protection, and operates below the lower explosive limit (LEL), qualifying the system for operation in hazardous areas. The thermal oxidation process is also far more easily controlled than a flame-based boiler because it may be operated over a wider range of fuel rates and is more tolerant of minor variations in fuel rates during operation.

[0033] Before the #2 diesel enters storage tank 80, chemical additives from a source 40 may be added to stabilize the #2 diesel product by preventing the formation of reactive molecules such as diolefines which can add an objectionable color to the #2 diesel product. Furthermore, #2 diesel fuel product will often darken over time due to the presence of reactive olefins within the fuel. To prevent this discoloration, well known fuel stabilizers such as Stabil-AD 5300 oil additive, produced by Malco Chemical Company of Naperville, Ill., have been found to stabilize the olefins when added according to the manufacturer's directions to the #2 product. The thermal cracking process described produces a #2 diesel fuel suitable for both highway and non-highway use.

[0034] The preferred process uses a pump to periodically inject preheated feedstock into the cracking vessel. Likewise, an additional pump is used to periodically withdraw materials from the bottom of the cracking vessel. As a result of the near continuous flow of material into and from cracking vessel, there is constant variation in the makeup of the material which is contained in the cracking vessel. Preferably, the cracking process is carried out at a pre-selected temperature and reflux rate. It has been observed that at any one instance, the collected product from the distillation column may not meet the specifications for the #2 diesel fuel. However, such short term fluctuations are transient and the aggregate distillation product does meet the requirements for #2 diesel fuel.

EXAMPLE ONE

[0035] The tallow was purchased per the specifications provided by the British Government from a company, Taylor By Products, in Pennsylvania and trucked down to Charleston. As the tallow was solid, steam was applied to the truck heating system which brought the tallow to a liquid at 160° F. The tallow was processed as a single feedstock stream. The processing yields were 83% #2 diesel fuel with flash point of 145° F. and perfect distillation curve. The pour point was measured down to -18° F. and the end product was almost clear. The lowest temperature for attained was only -18° F. as it was the lowest temperature achievable on site. The actual pour point is expected to be lower. The tallow-derived product had no sulphur at all and it is anticipated that the mixture for biodiesel should be something on the order of 40% tallow diesel mixed with refined mineral diesel, i.e., diesel purchased to blend with or diesel made from waste oils as described in U.S. Pat. No. 5,885,999.

EXAMPLE TWO

[0036] In order to gain greater detail on the resulting product a laboratory scale process was set up mimicking the foregoing conditions.

Laboratory Methodology

[0037] 1. A flow microreactor (11.5 mm×400 mm) was used for all studies. As the flow rates of the feed material were low, we used N₂ as the co-feed to feed tallow in the reactor. Similar techniques have been used in earlier similar type of work. This technique helped to distribute the feed material evenly as well as it prevents any thermal gradients in the reactor. FIG. 1 shows a simple schematic diagram of the reactor set up.

[0038] Also, by varying the co-feed N₂ flow, the residence time in the reactor could be varied. Residence time also was an important variable.

[0039] Temperature was the major variable for this study with a thermal cracking over the temperature range 200-600° C.

[0040] Several runs were carried out at 800° C. to determine the final pyrolysis gaseous products as well. The objective was to optimize the production of diesel fraction (boiling point range between 204-343° C.) in the liquid product.

[0041] 2. Gas product was analyzed using a GC.

[0042] 3. Attempts were made to analyze some liquid product samples using GC and GC/MS methods. Other characteristics/properties mentioned under 'Objectives' also were carried out.

[0043] It should be noted that there is no sulfur content in tallow or vegetable oil. The #2 diesel fuel is therefore suitable for use in automobiles. The above results leads applicant to believe that the process can be carried out across a wide range of temperatures, including temperatures, lower or higher than those set out above, yet still produce high quality #2 diesel fuel.

[0044] In carrying out the above process, it has been found desirable to select an initial cracking temperature for the cracking vessel and to maintain that temperature over a prolonged time period. To accomplish this, applicant's preferred process uses a programmable logic controller provided by a Siemens/Texas Instruments 545 controller in conjunction with Interact software produced by Computer Technology Corporation, Charleston, S.C. It is well within the ordinary skill level of one trained in computers and computer software to provide a programmable logic controller and software which is capable of monitoring and automatically adjusting flow rates, temperature and temperature adjustments, pump operations, feed and withdrawal rates, reflux rates, and monitoring sensors which may be desirable on various components of the apparatus used to carry out the above process. It is thus seen that the present process provides for a method of converting said tallow into a diesel fuel product.

[0045] To demonstrate the efficacy of the process, the product produced was tested by Earth Sciences. The results were as follows:

[0046] Specifications established by ASTM Diesel Fuel Oil (ASTM-D-975)

[0047] Feed stock processed: tallow containing 2.3% water

[0048] Color: 1

[0049] Cold Filter Plugging Point ° C.: -17.3

[0050] Cloud Point ° C.: -8.2

[0051] Particulate Solids (mg/kg): 1

[0052] Transparency & Brightness: Clear & Bright

[0053] Oxidation Stability: 6.55

[0054] Residue: 0.05

[0055] Flash Point ° C.: 62.5

[0056] Water & Sediment: 0.0

[0057] Ash % mass: 0.0

[0058] Sulfur, % mass: 0.0

[0059] Cetane Number: 54

[0060] Distillation curve: 90% 333-512° F.

[0061] The most important element of this test is the distillation curve and the product yield, meeting the ASTM specifications for No. 2 diesel fuel. The yield was 83.2% which fell within the curve range of 333-512° F. The actual yield analysis was:

[0062] Water: 2.3%

[0063] Diesel: 83.2%

[0064] Light gases: 14.5%

[0065] Note that the light gases were burned in the plant thermal oxidizer along with the water at 1900° F. to produce the heat for the process and to incinerate controlled emissions.

[0066] Stack exit emission temperature: 870° F.

[0067] The key findings are: flash point, distillation curve, diesel yield, and sulfur.

[0068] The test results show that the tallow processed to within the specs of No.2 diesel fuel far exceed the minimum quality standards of ASTM for Class 1 diesel fuel.

[0069] While the invention has been described, disclosed, illustrated and shown in various terms or certain embodiments or modifications which it has assumed in practice, the scope of the invention is not intended to be, nor should it be deemed to be, limited thereby and such other modifications or embodiments as may be suggested by the teachings herein are particularly reserved especially as they fall within the breadth and scope of the claims hereto appended.

What is claimed is:

1. A process for cracking tallow into diesel fuel comprising:

thermally cracking the tallow in a cracking vessel at a temperature that ranges from 500 to 700° F. at ambient pressure and in the absence of a catalyst to yield in part cracked hydrocarbons;

separating the cracked hydrocarbons in a distillation column from other products of cracking; and

collecting the cracked hydrocarbons as diesel fuel.

2. The process of claim 1, in which cracking the tallow in the cracking vessel further yields a gas fraction that is consumed to fuel the process.

3. The process of claim 1, which further comprises:

maintaining a cracking temperature in the cracking vessel by continuous introduction into the cracking vessel of additional preheated tallow; and

continuously withdrawing cracked hydrocarbons from the cracking vessel.

4. The process of claim 2 which further comprises using a thermal oxidizer fueled by the gas fraction to generate heat for the process.

5. The process of claim 4 which further comprises supplying a constant stream of preheated tallow to a heat recovery device which receives heat from the thermal oxidizer to further preheat the tallow creating a stream of additionally preheated tallow which is thus heated to at least the cracking temperature.

6. The process of claim 5 which further comprises continuously introducing the additionally preheated tallow into the cracking vessel in an amount to compensate for cracked hydrocarbons and other products of cracking removed from the cracking vessel to maintain a volume of tallow in the cracking vessel.

7. The process of claim 1 in which the products of cracking include a vaporized fraction that comprises cracked hydrocarbons and light ends, and which further comprises

separating the light ends from the vaporized fraction to leave a remaining portion that constitutes a diesel fuel.

8. The process of claim 1, wherein the diesel fuel comprises a No. 2 diesel fuel.

9. The process of claim 1, wherein the tallow contains water preferably in a range of 2 to 7%.

10. The process of claim 5, which further comprises, prior to further preheating of the tallow by the heat recovery device, initially heating the tallow to a first temperature by passing the tallow through at least one heat exchanger which is supplied with heat from at least one of collected diesel fuel and a portion of liquid fraction withdrawn from the cracking vessel.

11. The process of claim 10, wherein the first temperature is preferably 500° F.

12. The process of claim 7, wherein the vaporized fraction of hydrocarbons enters the distillation column directly from the cracking vessel.

13. The process of claim 1, wherein the cracking temperature is preferably in a range of 625 to 700° F.

14. The process of claim 5, wherein a first fuel oil is withdrawn at a rate within a range of 0% to 10% in relation to a rate at which additionally preheated tallow is introduced.

15. A process for cracking tallow into a plurality of fuel oils comprising:

thermally cracking the tallow in a cracking vessel at a temperature that ranges from 625 to 700° F. at ambient pressure and in the absence of a catalyst to yield a vaporized fraction of cracked hydrocarbons and a liquid fraction of a fuel oil other than diesel;

collecting the fuel oil other than diesel;

separating the vaporized fraction of cracked hydrocarbons in a distillation column from other products of cracking; and

collecting the cracked hydrocarbons as diesel fuel.

16. The process of claim 15, in which cracking the tallow in the cracking vessel further yields a gas fraction that is consumed to fuel the process.

17. The process of claim 15, which further comprises:

maintaining a cracking temperature in the cracking vessel by continuous introduction into the cracking vessel of additional preheated tallow; and

continuously withdrawing cracked hydrocarbons from the cracking vessel.

18. The process of claim 16 which further comprises using a thermal oxidizer fueled by the gas fraction to generate heat for the process.

19. The process of claim 18 which further comprises supplying a constant stream of preheated tallow to a heat recovery device which receives heat from the thermal oxidizer to further preheat the tallow creating a stream of additionally preheated tallow which is thus heated to at least the cracking temperature.

20. The process of claim 19 which further comprises continuously introducing the additionally preheated tallow into the cracking vessel in an amount to compensate for cracked hydrocarbons and other products of cracking removed from the cracking vessel to maintain a volume of tallow in the cracking vessel.

21. The process of claim 15 in which the products of cracking include a vaporized fraction that comprises cracked hydrocarbons and light ends, and which further comprises separating the light ends from the vaporized fraction to leave a remaining portion that constitutes a diesel fuel.

22. The process of claim 19, which further comprises, prior to further preheating of the tallow by the heat recovery device, initially heating the tallow to a first temperature by passing the tallow through at least one heat exchanger which is supplied with heat from at least one of collected diesel fuel and a portion of liquid fraction withdrawn from the cracking vessel.

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