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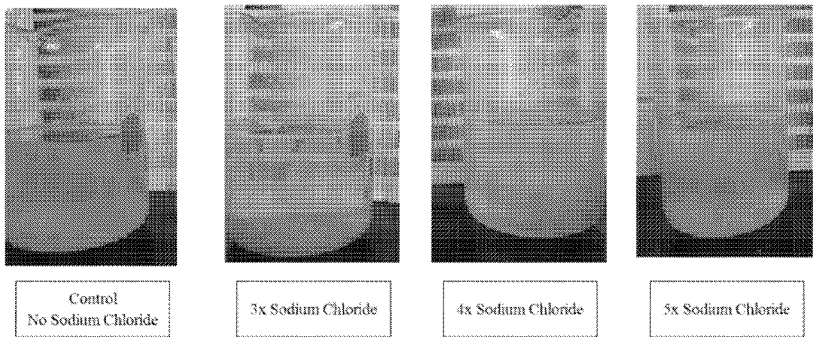


FIG. 1

(57) Abstract: Apparatus and related methods for reacting a natural oil and salt composition with a short chain alcohol in the presence of an alkaline catalyst to produce biodiesel, significantly decreasing the amount of time for the glycerol byproduct to settle out of the reaction mixture. The process for the production of biodiesel includes combining animal or vegetable oil with a salt to create a first component, combining a short chain alcohol with a strong base to create a second component, and combining the first and second components together. The combined compositions represent a reaction mixture that undergo a transesterification reaction and produce fatty acid methyl ester biodiesel and also a glycerol byproduct.

WO 2014/169192 A1

METHOD TO OPTIMIZE BIODIESEL PRODUCTION

This application claims benefit of and priority to U.S. Provisional Application No. 61/810,942, filed April 11, 2013, by Jeffery Thompson, et al., and U.S. Provisional Application No. 61/810,948, filed April 11, 2013, by Jeffery Thompson, et al., and is entitled to that filing date for priority. The specification, figures and complete disclosures of U.S. Provisional Application Nos. 61/810,942 and 61/810,948 are incorporated herein by specific reference for all purposes.

This invention was made with the support of the United States government under National Science Foundation Grant EEC-0908672. The Government has certain rights in this invention.

FIELD OF INVENTION

The present invention relates to methods and compositions utilized in the production of biodiesel.

BACKGROUND

The United States' addiction to petroleum based fuels is an ever present environmental problem and an increasingly heavy financial burden. Biofuels are one option that would help reduce the dependency upon petroleum fuels. Biodiesel is a type of biofuel that may provide an alternative fuel source to help replace petroleum fuels. Biodiesel is fuel made up of fatty acid alkyl esters, fatty acid methyl esters (FAME), or long-chain mono alkyl esters. Biodiesel can be made from a large array of fatty acids. The list of available raw materials utilized to produce biodiesel ranges from used cooking oil to liquefied chicken fat.

Biodiesel production is commonly done by transesterification of animal or vegetable oils/fats. Such oils and fats comprise triglyceride esters containing long chain fatty acid moieties. In biodiesel synthesis, such triglycerides are transesterified with short chain alcohols, typically methanol and sometimes ethanol, though other alcohols have been used. The reaction can be carried out in the presence of an acidic or basic catalyst and in general the basic catalysts are faster, with sodium

hydroxide or potassium hydroxide being most commonly used. Typically, sodium or potassium hydroxide with a relatively low water level is mixed with the alcohol, for example methanol, and the mixture is then mixed with the oil. Glycerol is a byproduct of the transesterification reaction.

Once the transesterification reaction is complete, the glycerol byproduct must be given time to settle out. The amount of time required for the glycerol to settle out of the reaction mixture is one limiting factor in the production of biodiesel that causes problems when trying to produce the fuel on an industrial scale. It takes approximately eight hours for the byproduct glycerol to sufficiently settle out of the reaction mixture, such that a suitable biodiesel fatty acid methyl ester may be retrieved. Other factors, such as the speed of the transesterification reaction itself, also present problems in deriving a biodiesel production technique that is efficient enough for industrial scalability.

In the production of biodiesel, the cost of the oil or grease is the single largest component of production costs. Yellow grease, which is used vegetable oil from the fast-food industry, is much less expensive then soybean oil but has a very limited supply. Yellow grease is estimated to cost roughly $1.55 per gallon in the year 2012-2013 versus $2.80 per gallon for soybean oil. In 2011, the U.S. biodiesel industry reached a milestone by producing over 1 billion gallons of fuel. This is just a small amount compared to the 33 billion gallons of on-highway diesel consumed by the United States annually. In addition, the current price of a gallon of soybean oil is up to three times the cost of diesel fuel. Even though the potential market for the glycerol byproduct offsets some of these costs, it still makes biodiesel less economically feasible in comparison to conventional diesel fuels.

Despite the greater price, there are many reasons that biodiesel should still be developed. One such reason is that the exhaust emissions from biodiesel are significantly lower than those of regular diesel fuel. Another is that when biodiesel is added in a 1-2% amount to regular diesel fuel it can give the fuel better lubricating properties. Thus, biodiesel production is still being considered in the United States and Europe as an alternative fuel.

In biodiesel production plants, generally, the reaction takes place in either a batch reactor or continuously stirred tank reactors. With a batch reactor, a 6:1 ratio of alcohol to triglycerides is used and the reactor is operated at around 65 °C. The reaction will take anywhere from twenty minutes to an hour to be complete. In some processes, the batch is left in the reaction vessel to initially settle the biodiesel and glycerol byproduct, while in other processes the batch is pumped into a settling vessel or a centrifuge.

Another way biodiesel is produced in industry is through a continuous process system. A continuous system consists of continuously stirred tank reactors (CSTR) in series. The reaction is carried out normally in a first CSTR; afterwards, the initial glycerol is decanted. After this glycerol is separated out, the reaction in a second CSTR occurs at a faster rate with a greater percent completion. The disadvantage of the continuous system is that there must be enough mixing to sustain a continuous composition throughout the reactor. This means that the dispersion of glycerol in the biodiesel phase is greater and, therefore, it will require more time to settle out of the layer.

After the biodiesel and glycerol are produced in the reactor, they must be separated through a unit operation that speeds up the natural settling of the phases. Centrifuge systems, decanters, and hydrocyclones are most commonly used for this purpose. Decanters rely on density differences between the two phases and residence time to achieve separation. However, the size of the decanter is a function of the residence time. This means that the only way of decreasing time of separation is to increase the size of the decanter, which in turn increases the cost of the process equipment. These systems are usually only used in small batch processes, where the longer residence time is acceptable. Centrifugal systems are mostly used in continuous biodiesel processes. The centrifuge separates biodiesel and glycerol by creating an artificial gravity field by spinning at a high velocity. The centrifuge is used extensively in industries, but is expensive due to initial costs and maintenance. Hydrocyclones are considered to be an effective, but still experimental, method of ester-alcohol

separation. The liquid mixture enters the hydrocyclone at a high pressure, and then passes from a wide to narrower section of the inverted cone where the pressure decreases and velocity increases. This causes an increase in gravitational forces, which causes the denser liquid, glycerol, to be accelerated towards the wall while biodiesel, the lighter liquid, is concentrated in the center.

Even though most current separation operations use the difference in densities to separate the phases, there are new technologies that use ultrasonic energy. These ultrasonic processing apparatuses achieve separation by applying ultrasonic energy at two different frequencies to the reactant fluid. The sonic waves transmit through the walls and into the reactants where it accelerates the transesterification and separation processes within the tank. These devices can produce biodiesel at a continuous rate, up to one gallon per minute with a power of 5000 watts. While they do increase reaction and separation times, they do have the disadvantage of being very expensive. As of yet, there are no single ultrasonic processors that can handle enough biodiesel that would be produced in a large production plant. Instead, multiple ultrasonic processors would have to be used, leading to a high initial cost.

The time consumed producing biodiesel can be marginally lessened by a variety of techniques; however, the techniques currently used in the art also increase the cost of production (e.g., the cost of materials and/or energy required). The cost/benefit ratio of producing biodiesel has been a primary reason for the lack of commercially produced biodiesel in the United States.

If a low cost method were available to decrease the production time associated with the manufacture of biodiesel, then such a method would have a great impact on making the production of biodiesel on an industrial scale commercially viable.

Thus, there is a need in the art for a biodiesel production method that decreases the time of producing the fuel. In particular, methods that decrease the amount of time for the glycerol byproduct to settle out of the reaction mixture are needed.

SUMMARY OF INVENTION

In various exemplary embodiments, the present invention comprises a method of biodiesel production that significantly decreases the amount of time taken for the glycerol byproduct to settle out of the reaction mixture. The present methods and compositions utilized herein provide an efficient biodiesel production platform that can be scaled up to industrial size. Therefore, the methods and compositions presented herein fulfill a need in the art of biodiesel production and represent a pathway to producing a commercially viable alternative to petroleum based fuels.

Thus, in an embodiment, a process for the production of biodiesel is provided comprising: a) combining animal or vegetable oil with salt (e.g., sodium chloride) to create a first composition, b) combining a short chain alcohol with a strong base to create a second composition, and c) combining said first and said second compositions together. The combined compositions represent a reaction mixture that will undergo a transesterification reaction and produce fatty acid methyl ester biodiesel and also a glycerol byproduct.

In particular embodiments the short chain alcohol used in the method is methanol (MeOH) or ethanol (EtOH).

In some embodiments the strong base is sodium hydroxide (NaOH) and in other embodiments the strong base is potassium hydroxide (KOH). Preferably, the strong base is anhydrous.

The stoichiometric ratio of salt utilized in embodiments of the method can range from 1x to 10x, 1x to 9x, 1x to 8x, 1x to 7x, 1x to 6x, 1x to 5x, 1x to 4x, 1x to 3x, and 1x to 2x. A preferred embodiment of the method utilizes a 3x stoichiometric ratio of sodium chloride as the salt.

In embodiments of the method the first and second compositions are heated to about 40ºC to about 65ºC, or about 45ºC to about 60ºC, or about 50ºC to about 55ºC, and then combined. In another embodiment, the first and second compositions are combined at room temperature and then heated.

In some aspects of the method, after the first and second compositions are combined, the temperature of the combined reaction mixture is held in a range of about 40°C to about 65°C, or about 45°C to about 60°C, or about 50°C to about 55°C, for a duration of about 30 minutes to about 90 minutes, or about 40 minutes to about 70 minutes, or in some aspects, the temperature of the combined reaction mixture is maintained continually.

Furthermore, the present disclosure provides a method of reacting a natural oil with a short chain alcohol in the presence of an alkaline catalyst, comprising: providing a natural oil, providing a salt (e.g., sodium chloride), providing a short chain alcohol, providing an alkaline catalyst, and then combining the natural oil with the sodium chloride into a composition (a), and also combining the short chain alcohol with the alkaline catalyst into a composition (b), and subsequently combining composition (a) and composition (b) into a combined reaction mixture. The combined compositions represent a reaction mixture that will undergo a transesterification reaction and produce fatty acid methyl ester biodiesel and also a glycerol byproduct.

In some embodiments the natural oil is vegetable oil, the short chain alcohol is methanol, and the alkaline catalyst is sodium hydroxide.

It is a further object of the disclosure to provide a biodiesel produced by the disclosed processes.

In other aspects, the disclosure provides for fatty acid methyl esters produced by the disclosed processes.

In yet other embodiments, a reaction product that is produced by the disclosed processes is provided.

It is understood that sodium chloride is not the only salt that may be utilized in the taught methods; rather, any water-soluble salt may be utilized in the taught methods (for example, and without limitation, LiCl, KCl, RbCl, $MgCl_2$, NaBr, NaI, NaF, $NaNO_3$, and Na_2SO_4).

Another object of the disclosure is to provide compositions useful for transesterification reactions. In some aspects, these compositions comprise sodium chloride and vegetable oil. In other aspects, these compositions comprise methanol and sodium hydroxide. In yet other aspects, the compositions comprise sodium chloride, vegetable oil, methanol, and sodium hydroxide.

While certain novel features of this disclosure shown and described below are pointed out in the annexed claims, the disclosure is not intended to be limited to the details specified, since a person of ordinary skill in the relevant art will understand that various omissions, modifications, substitutions, and changes in the forms and details of the disclosure illustrated and in its operation may be made, without departing in any way from the spirit of the present disclosure. No feature of the disclosure is critical or essential unless it is expressly stated as being "critical" or "essential." These and other features, aspects, and advantages of embodiments of the present disclosure will become better understood with regard to the following description, claims, and accompanying drawings explained below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates the separation of the glycerol byproduct layer from the fatty acid methyl ester biodiesel layer. Each sample was photographed 20 minutes after neutralization of the reaction occurred. The figure illustrates the effect of a biodiesel production method that utilizes no sodium chloride (control) in the production process as well as a biodiesel production method that utilizes sodium chloride at a stoichiometric ratio of 3x, 4x, and 5x. The sodium chloride is combined with the vegetable oil and subsequently combined with the composition comprising methanol and sodium hydroxide.

FIG. 2 shows Fourier-Transform Infrared (FTIR) spectra illustrating the settling time profile of a biodiesel batch produced without the addition of sodium chloride in Panel A. FIG. 2 illustrates the settling time profile of a biodiesel batch produced with 3x sodium chloride in Panel B. Alcohol in the

form of glycerol can be seen at the wavenumber of approximately 3300 cm^{-1}. A lower glycerol peak indicates that less glycerol byproduct is entering the methyl ester biodiesel phase.

FIG. 3 provides FTIR spectra showing on the same graph both: (1) a modified sample that utilized 3x sodium chloride during production of the biodiesel, and (2) an unmodified control sample that utilized no sodium chloride during production of the biodiesel. Alcohol in the form of glycerol can be seen at a wavenumber of approximately 3300 cm^{-1}. The glycerol peak is significantly higher in the unmodified control sample, indicating that more glycerol byproduct is present in the methyl ester biodiesel phase. The glycerol peak is significantly lower in the modified 3x sodium chloride sample, indicating that less glycerol byproduct is present in the methyl ester biodiesel phase.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Detailed descriptions of one or more preferred embodiments are provided herein. It is to be understood, however, that the present invention may be embodied in various forms. Therefore, specific details disclosed herein are not to be interpreted as limiting, but rather as a basis for the claims and as a representative basis for teaching one skilled in the art to employ the present invention in any appropriate manner.

Biodiesel is a time intensive production process. Finding ways to shorten the production time can greatly impact the feasibility of large scale industrial production. The present methods utilized sodium chloride addition to the biodiesel production process in order to achieve significant reductions in the time taken to produce biodiesel. The sodium chloride utilized in the below methods allowed the settling time of the glycerol byproduct to be reduced from 8 hours to merely 20-30 minutes.

In brief, sodium chloride addition was examined at different stoichiometric ratios, of 1x, 2x, 3x, 4x, and 5x, in relation to total reaction components. Reaction time was kept constant at 60 minutes. Amounts of methanol, vegetable oil, and sodium hydroxide catalyst were also kept constant. An

optimal condition for producing biodiesel was found using sodium chloride at a stoichiometric ratio of 3x the total reaction components.

In one exemplary embodiment, to derive a first composition, a short chain alcohol and strong base were mixed together. The short chain alcohol utilized was methanol, and sodium hydroxide was the chosen strong base.

Using a ceramic mortar and pestle, sodium hydroxide was ground into a fine powder to decrease the time needed to dissolve. This was completed in a plastic bag to keep the hygroscopic nature of the sodium hydroxide from pulling water from the surrounding air.

The methanol and crushed sodium hydroxide were mixed together in a 500 mL Erlenmeyer flask. A hot plate and mixer with a magnetic stir bar was used to conduct the mixing. Parafilm was used to prevent evaporation. While the mixture was spun vigorously, heat was applied to warm up the MeOH/NaOH solution to 55°C. Once the 55°C temperature was reached and verified, the MeOH/NaOH solution was measured and separated out into graduated cylinders. The cylinders were capped with parafilm.

To derive a second composition, a natural oil and sodium chloride were mixed together. Further, as a control, a second composition was derived that did not utilize the sodium chloride and only contained the natural oil. The natural oil utilized was vegetable oil.

1000 mL beakers where used to heat the vegetable oil and sodium chloride composition until the temperature reached 50°C. The same procedure was used to heat the control composition comprising only the vegetable oil and lacking the sodium chloride.

Once the vegetable oil composition temperature reached 50°C, the MeOH/NaOH composition (i.e., the first composition) was added to the vegetable oil composition (i.e., the second composition). The mixing rate was increased to create a whirlpool that did not touch the bottom of the beaker. During the 60 minute transesterification reaction process, the temperature was monitored and when the

temperature reached 56°C the hot plate was turned off; when the temperature reached 53°C the hot plate was then turned back on. In this manner, a reaction temperature in the range of about 50°C to about 55°C was maintained.

After 60 minutes the biodiesel batch was neutralized with six mL of 6 N H_2SO_4. The batch was stirred for one minute after neutralization. Finally, the beakers were moved to a visual settling station and allowed to settle.

The experiment was conducted doing two batches at once. Two hot plate stirrers were set up side by side. For data collection, aliquots were taken both during the process at set time intervals and during the settling. Using a Micropipette, a 1 mL sample was taken one minute after the MeOH/NaOH composition was added to the oil or oil/NaCl compositions. One mL aliquots were also taken at 20 minutes, 40 minutes, and 60 minutes post MeOH/NaOH addition.

Once a sample was taken, the 6 N H_2SO_4 was used to neutralize the sodium hydroxide catalyst and preserve the exact state of the reaction. Once all the reaction samples were taken, neutralized, and stored, the leftover batch was neutralized with 6 mL of the H_2SO_4. The magnetic stir bar was left spinning for one minute to ensure complete mixing. The sample was then taken to an area were a visual dispersion chart was located. This chart was used to help identify the difference in the clarity of the biodiesel. One mL aliquots were taken every five minutes for 30 minutes after the neutralization of the batch. A micropipette was used for collection, and aliquots were collected from the same depth of the batch to ensure accurate samples. FTIR spectroscopy was used to determine the presence of alcohol and other compounds indicative of the glycerol byproduct settling process.

During biodiesel production, the glycerol byproduct normally requires approximately 8 to 15 hours of settling time. For these experiments, each sample was photographed 20 minutes after neutralization occurred. The results are depicted in FIG. 1. The dramatic improvement in settling time of the glycerol byproduct achieved utilizing the methods and compositions of the present disclosure

can be seen in FIG. 1. Specifically, the 3x sodium chloride treatment demonstrated the best results, as a clear visual separation can be observed between the glycerol byproduct layer and the biodiesel layer. Note the visual chart behind each flask that allows a ready comparison between the treatments. The 3x sodium chloride treatment allows for an easy delineation of the visual chart.

IR spectroscopy emits an energy pulse into a sample at varying wavelengths. Depending on the molecular structure of a compound, certain wavelengths are absorbed. Data from the sensor is then plotted and the plot illustrates the levels of the wavelength that have been absorbed. Using Beers law, one can infer concentration in the sample.

The IR spectroscopy corroborates the visual observations and conclusions made previously. Alcohol in the form of glycerol can be seen at the wavenumber of approximately 3300 cm^{-1}. With time, the glycerol settles to the bottom of the sample. The ester bonds that are created to form biodiesel can be seen at the wavenumber of approximately 1750 cm^{-1}. With time, the concentration of ester bonds should increase. These two compounds represent the creation of biodiesel. FIG. 2, in Panel A, depicts the stages of the settling process of the unmodified control sample (*i.e.* no sodium chloride) for the production of biodiesel over time. The times used are 1 hour, 3 hours, 5 hours, 8 hours, 12 hours, and 24 hours. FIG 2, in Panel B, depicts the stages of the settling process of the modified reaction sample (i.e., comprising 3x sodium chloride) at 5 minutes, 15 minutes, and 30 minutes.

The concentrations of glycerol have lower concentration, in a shorter time span, in the sample that utilized 3x sodium chloride in the reaction procedure (FIG. 2, Panel B), as compared to the unmodified control sample (FIG. 2, Panel A) that did not utilize sodium chloride. A lower glycerol peak indicates that less glycerol byproduct is entering the methyl ester biodiesel phase. In FIG. 3, FTIR spectra of the modified sample that utilized 3x sodium chloride and the unmodified control sample are presented on the same graph. These samples represent 30 minutes of settling time. The

peak at the alcohol wavenumber is significantly higher in the unmodified control sample, indicating that more glycerol byproduct is present in the methyl ester biodiesel phase when sodium chloride is absent from the production process. In contrast, the glycerol peak obtained in the 3x sodium chloride sample is significantly lower than the glycerol peak of the control sample, indicating that less glycerol byproduct is present in the methyl ester biodiesel phase when sodium chloride is present in the production process.

Thus, a biodiesel production method that utilizes a 3x sodium chloride concentration can reduce the settling time of a biodiesel production batch from 8 hours to 20 minutes.

In several alternative embodiments, the components are mixed in the presence of a mesh, such that the mesh is in contact with the combined components. The mesh material that is present during the transesterification reaction decreases the amount of time required for the glycerol byproduct to settle out of the reaction mixture. The mesh material, in some embodiments, is present in the interior cavity of a batch reactor. In other embodiments, the mesh material is found lining the walls of the batch reactor. In yet other embodiments, the mesh material is incorporated into a stirring mechanism, said stirring mechanism being placed within the batch reactor and providing a means for stirring the reaction components. Thus, the mesh material can be located in any position within the reaction container, so long as the mesh material is in contact with the transesterification reaction components. Those of skill in the art will appreciate the myriad embodiments that can be developed for incorporating a mesh material into a batch reactor. Furthermore, the mesh material may also be incorporated into the interior of a continuous reaction vessel, such as a continuously stirred tank reactor (CSTR).

The mesh material may comprise, in certain embodiments, a metal, a polymer, or both. For instance, some embodiments utilize a nickel mesh material, other embodiments comprise a plastic mesh material, and yet other embodiments utilize a mesh material comprising both nickel and plastic.

However, virtually any metal or plastic material may be utilized in the mesh. The mesh may comprise various sizes and shapes of apertures located within said mesh material. In other words, the mesh apertures may vary in size and shape within a portion of mesh material, or they may be of uniform shape and size. Further, the mesh material itself may be any size and shape.

Thus, it should be understood that the embodiments and examples described herein have been chosen and described in order to best illustrate the principles of the invention and its practical applications to thereby enable one of ordinary skill in the art to best utilize the invention in various embodiments and with various modifications as are suited for particular uses contemplated. Even though specific embodiments of this invention have been described, they are not to be taken as exhaustive. There are several variations that will be apparent to those skilled in the art.

CLAIMS

What is claimed is:

1. A process for the production of biodiesel, comprising:

    a) combining animal or vegetable oil with a salt to create a first composition;

    b) combining a short chain alcohol with a strong base to create a second composition; and

    c) combining said first and second compositions together.

2. The process of claim 1, wherein the short chain alcohol is methanol or ethanol.
3. The process of claim 1, wherein the strong base is sodium hydroxide or potassium hydroxide.
4. The process of claim 1, wherein the salt is present in a stoichiometric ratio range of about 1x to about 5x relative to the other components present in the first and second compositions.
5. The process of claim 1, wherein the salt is present in a stoichiometric ratio of 3x relative to the other components present in the first and second compositions.
6. The process of claim 1, wherein the first and second compositions are each heated to about 50°C to about 55°C before being combined.
7. The process of claim 1, wherein the first and second compositions are each heated to about 45°C to about 60°C before being combined.
8. The process of claim 1, wherein the first and second compositions are each heated to about 40°C to about 65°C before being combined.
9. The process of claim 1, wherein after the first and second compositions are combined, said combination is heated to about 50°C to about 55°C and the temperature is maintained in said range for about 30 minutes to about 90 minutes.

10. The process of claim 1, wherein after the first and second compositions are combined, said combination is heated to about 50°C to about 55°C and the temperature is maintained in said range for about 40 minutes to about 70 minutes.
11. The process of claim 1, wherein after the first and second compositions are combined, said combination is heated to about 45°C to about 60°C and the temperature is maintained in said range for about 40 minutes to about 70 minutes.

12. A method of reacting a natural oil with a short chain alcohol in the presence of an alkaline catalyst, comprising:

    i) providing a natural oil;

    ii) providing a salt;

    iii) providing a short chain alcohol;

    iv) providing an alkaline catalyst;

    v) combining the natural oil with the sodium chloride into a composition (a);

    vi) combining the short chain alcohol with the alkaline catalyst into a composition (b); and

    vii) combining compositions (a) and (b).

13. The method of claim 12, wherein the natural oil is vegetable oil.
14. The method of claim 12, wherein the short chain alcohol is methanol.
15. The method of claim 12, wherein the alkaline catalyst is sodium hydroxide.
16. The method of claim 12, wherein the salt is present in a stoichiometric ratio range of about 1x to about 5x relative to the other components present in the compositions (a) and (b).

17. The method of claim 12, wherein the salt is present in a stoichiometric ratio of 3x relative to the other components present in the compositions (a) and (b).
18. The method of claim 12, wherein composition (a) and composition (b) are each heated to about 50°C to about 55°C before being combined.
19. The method of claim 12, wherein composition (a) and composition (b) are each heated to about 45°C to about 60°C before being combined.
20. The method of claim 12, wherein composition (a) and composition (b) are each heated to about 40°C to about 65°C before being combined.
21. The method of claim 12, wherein after composition (a) and composition (b) are combined, said combination is heated to about 50°C to about 55°C and the temperature is maintained in said range for about 30 minutes to about 90 minutes.
22. The method of claim 12, wherein after composition (a) and composition (b) are combined, said combination is heated to about 50°C to about 55°C and the temperature is maintained in said range for about 40 minutes to about 70 minutes.
23. The method of claim 12, wherein after composition (a) and composition (b) are combined, said combination is heated to about 45°C to about 60°C and the temperature is maintained in said range for about 40 minutes to about 70 minutes.
24. A biodiesel produced by the process of claim 1.
25. A fatty acid methyl ester produced by the process of claim 1.
26. A reaction product produced by the method of claim 14.
27. A reaction product produced by the method of claim 14, wherein said reaction product is a fatty acid methyl ester.

28. A process for the production of biodiesel, comprising:

a) combining animal or vegetable oil with chloride salt to create a first composition;

b) combining a short chain alcohol with a strong base to create a second composition; and

c) combining said first and second compositions together.

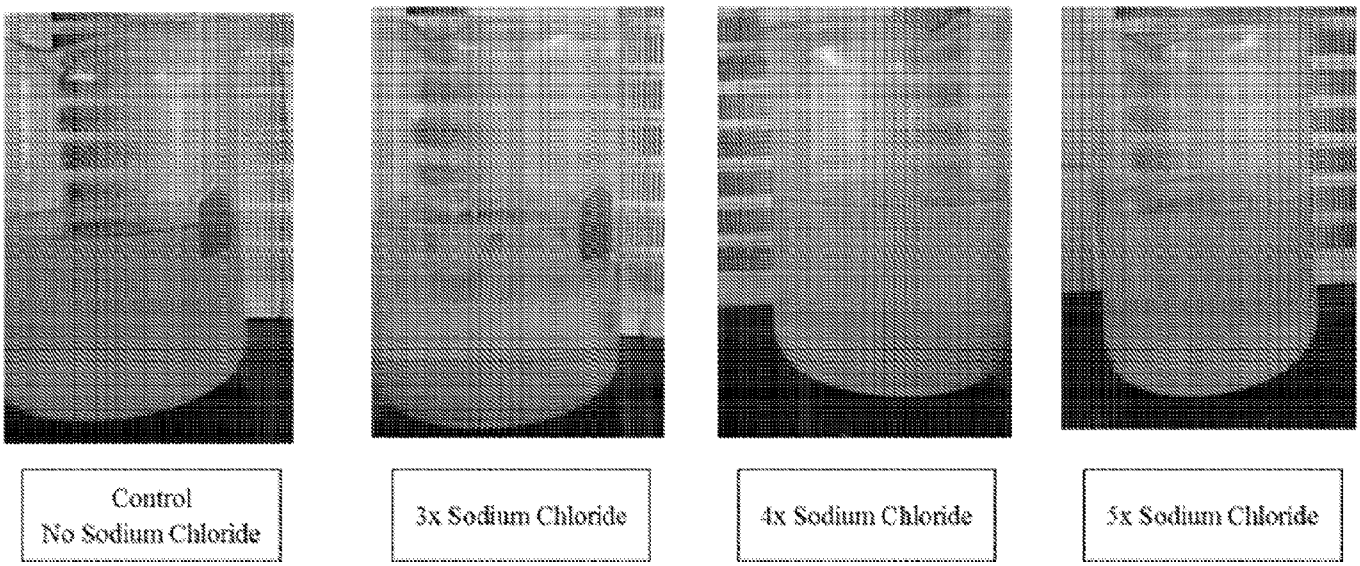
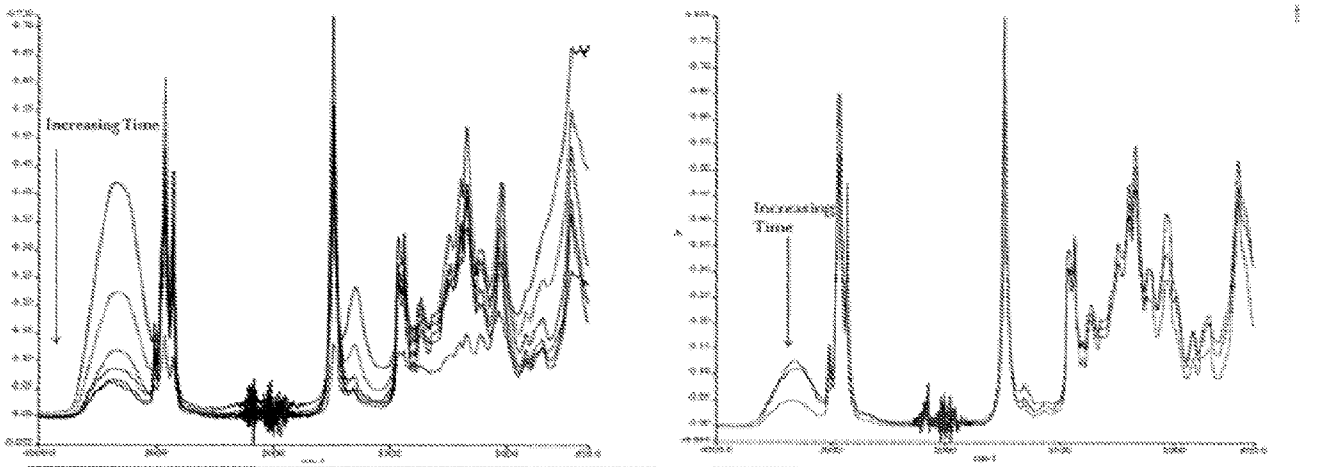

Control
No Sodium Chloride
3x Sodium Chloride
4x Sodium Chloride
5x Sodium Chloride

FIG. 1



Panel A
Control Protocol Settling Time Profile of Biodiesel Production for 30 Minutes

Panel B
3x Sodium Chloride Protocol Settling Time Profile of Biodiesel Production for 30 Minutes.

FIG. 2

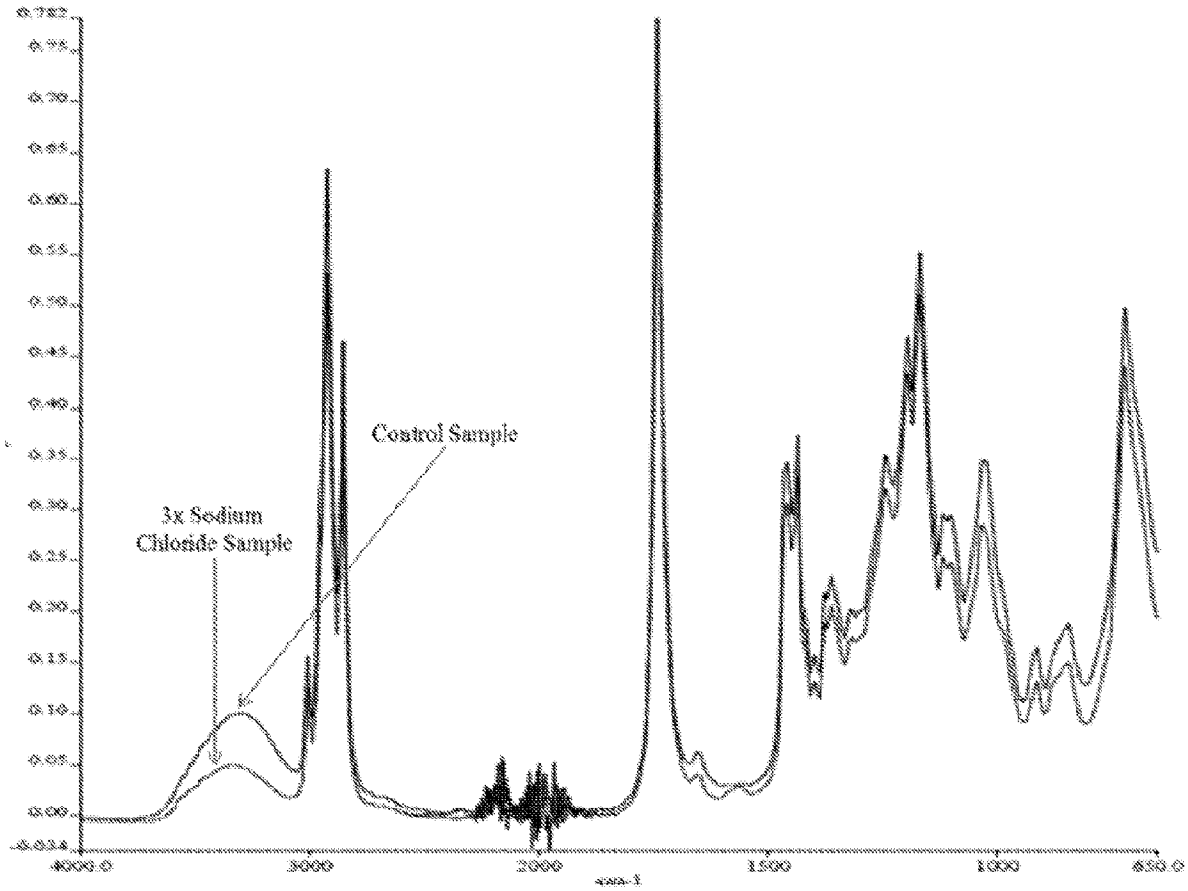

Control Sample
3x Sodium
Chloride Sample
4000.0
3000
2000
1500
1000
650.0

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/033769

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C11C 3/00 (2014.01)
USPC - 44/308
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(8) - C10L 1/00, 1/10, 1/18; C11B 3/00; C11C 3/00 (2014.01)
USPC - 44/307, 308, 605

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - C10L 1/10, 1/12, 1/18, 1/1802; C11C 3/003, 3/02 (2014.06)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Orbit.com, Google Patents, Google Scholar, Public AppFT and PatFT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/0038208 A1 (DESPEGHEL) 12 February 2009 (12.02.2009) entire document	1-28
Y	US 5,322,576 A (AITKEN et al) 21 June 1994 (21.06.1994) entire document	1-28
Y	US 2008/0202021 A1 (POWELL) 28 August 2008 (28.08.2008) entire document	12-23, 26, 27

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 July 2014	22 AUG 2014

Name and mailing address of the ISA/US	Authorized officer:
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