PRODUCTION OF BIODIESEL

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ABSTRACT
A process for the production of biodiesel is disclosed. In a preferred embodiment, the process is based on the production of biodiesel using refinery soapstock where the process is performed in an alcoholic medium resulting in the insolubility of certain byproducts. Other valuable products can also be obtained from the process.
PRODUCTION OF BIODIESEL

CROSS-REFERENCE TO RELATED APPLICATIONS


BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention
[0003] The present invention relates to a process for the production of biodiesel using soapstock.

[0004] 2. Description of the Related Art

[0005] Biodiesel is a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel is simple to use, biodegradable, and nontoxic. Biodiesel is comprised of mono-alkyl esters of long chain fatty acids. These mono-alkyl esters of long chain fatty acids have been derived from vegetable oils or animal fats.

[0006] The processes used today to produce the methyl or ethyl esters of fatty acids start from animal or vegetable oils (triglycerides), an esteemed material that has better application in human and/or animal food. Accordingly, because of the importance of animal and vegetable oils as food, the use of animal and vegetable oils in the energy matrix as raw material for the manufacture of biodiesel results in an overall waste.

[0007] Processes are available to use the fatty acids from soapstock, a residual by-product from the production of the edible oils and fats, to produce biodiesel. However, these processes produce a great quantity of residual acid-water due to the aciddulation of the soapstock with sulfuric acid. The residual water is acidic, has high sodium sulfate content, and has a very high Biochemical Oxygen Demand (BOD) because of the lecithin, gums, and other organic impurities present in the effluent water. The high cost of the treatment of the effluent water coming from the aciddulation of the soapstock makes the process economically unviable. The treatment of this residual effluent is an extremely complicated problem from an environmental point of view. The problem is technically difficult to solve because of the water’s high content of sodium sulfate and the high BOD resulting from the gums, lecithin, and other organic impurities.

SUMMARY OF THE INVENTION

[0008] Accordingly, there exists a need to turn the production of biodiesel from refinery soapstock into a feasible process from an economic and environmentally adequate point of view.

[0009] One embodiment provides a process for producing biodiesel comprising: saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock; filtering the solution of saponified soapstock to remove substantially insoluble organic material; adding a mineral acid to the filtered solution of saponified soapstock to form fatty acids and a mineral salt; and esterifying the fatty acids, thereby forming biodiesel.

[0010] Another embodiment provides biodiesel obtained from a process comprising: saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock; filtering the solution of saponified soapstock to remove substantially insoluble organic material; adding a mineral acid to the filtered solution of saponified soapstock to form fatty acids and a mineral salt; and esterifying the fatty acids.

[0011] Another embodiment provides sterols obtained from a process comprising: saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock; filtering the solution of saponified soapstock to remove substantially insoluble organic material; adding a mineral acid to the filtered solution of saponified soapstock to form fatty acids and a mineral salt; esterifying the fatty acids; removing insoluble impurities after the esterification; and distilling the solution of esters of fatty acids after esterification to obtain sterols.

[0012] Another embodiment provides organic material obtained from a process comprising: saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock; and filtering the solution of saponified soapstock to obtain substantially insoluble organic material.

[0013] Another embodiment provides mineral salts obtained from a process comprising: saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock; filtering the solution of saponified soapstock to remove substantially insoluble organic material; adding a mineral acid to the filtered solution of saponified soapstock to form fatty acids and a mineral salt; and separating the mineral salt from the solution.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0014] Preferred embodiments provide a process for the production of biodiesel utilizing soapstock as a starting material. Soapstock, as a refining oil byproduct, is an abundant, under-utilized, and inexpensive starting material. Advantageously, the preferred process to obtain biodiesel does not substantially use vegetable or animal oils as raw material, which could find better applications in animal and human food. Also, the preferred process is environmentally friendly, as the process does not generate large quantities of residual acid water. The preferred process also produces useful reagents, such as polypeptides, lecithin, sodium sulfate, and sterols.

[0015] As used herein, biodiesel refers to mono-alkyl esters of long chain fatty acids, preferably methyl or ethyl esters. Preferred biodiesel made from various starting materials with various processes can confirm to specifications. In the United States, the American Society of Testing and Materials (ASTM), a standard setting organization for fuels and fuel additives, defines biodiesel according to specifications.

[0016] As used herein, soapstock refers to a refining oil byproduct. Soapstock comprises a cache of plant esters (sterols), glycerides (oils), phospholipids (lecithin), sodium soap.

[0017] A preferred embodiment uses soapstock, a residual by-product from the production of edible oils and fats. While there are other processes available which also use the fatty acids from soapstock, in contrast to the preferred embodi-
ments, these other processes produce a great quantity of residual acid-water due to the acidulation of the soapstock with sulfuric acid. Accordingly, there exists a need to turn the production of biodiesel from refinery soapstock into a feasible process from an economic and environmentally adequate point of view.

[0018] The processes are based on the production of biodiesel from the soapstock of vegetable or animal oil refining. In one embodiment, the processes are preferably performed in an alcoholic medium, which results in the insolubility of byproducts. Consequently, certain problems of the prior art biodiesel productions, such as treatment of the residual water which is acidic, high sodium sulfate content, and high BOD, are bypassed.

[0019] In one embodiment, a process for producing biodiesel is disclosed. The process comprises: saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock; filtering the solution of saponified soapstock to remove substantially insoluble organic material; adding a mineral acid to the filtered solution of saponified soapstock to form fatty acids and a mineral salt; and esterifying the fatty acids, thereby forming biodiesel. The process can further comprise neutralizing excess mineral acid after addition of the mineral acid to the filtered solution. The process can further comprise removing salts formed from the neutralization. The process can further comprise removing the alcohol after esterification. The process can further comprise removing insoluble impurities after esterification. The process can further comprise distilling the esters of fatty acids after esterification.

[0020] In one embodiment, the process comprises the following steps:

[0021] (A) Treating a refinery soapstock with a strong alkaline base in the presence of an alcohol. The saponification of the triglycerides present in the refinery soapstock can be achieved by treating the soapstock with a strong alkaline base. This treatment can be conducted under heating and alcohol reflux. Substantial triglycerides present are saponified by the strong alkaline base.

[0022] (B) After finishing the reaction described in (A), the product is filtered to remove substantially insoluble organic material. This organic material comprises polypeptides and lecithin and can be used as an emulsifying agent in industrial applications or as an additive to animal feed.

[0023] (C) A strong mineral acid, such as, but not limited to, sulfuric, phosphoric, or chloride acid is then added to the alcoholic solution. The mixture is then heated to around the boiling point of the alcohol and refluxed. Fatty acids can form from the respective soaps.

[0024] (D) In the reaction described above, a mineral salt can form between the strong alkaline base component of the soap and the strong mineral acid. The salt is not soluble or sparingly soluble in an alcoholic medium, where the process is conducted. Accordingly, filtration and removal of the salt from the reactive medium is easy to perform. Generally, the filtered salt is a technical grade and can be sold for industrial applications.

[0025] (E) After filtering the salt, the material is heated under reflux for esterification of the free fatty acids with the alcohol already being used.

[0026] (F) After esterification, a certain quantity of base is added to neutralize the excess mineral acid in the alcoholic solution.

[0027] (G) After neutralization, the solution is filtered again to remove the salts formed during the neutralization.

[0028] (H) The clear solution of esters in alcohol is ready for the removal of the excess of alcohol. This removal can be done by distillation of the alcohol.

[0029] (J) After recovering the excess alcohol, insoluble impurities are removed from the esters.

[0030] (K) The ester obtained after removal of insoluble impurities is then distilled for purification resulting in biodiesel.

[0031] In another embodiment, the process comprises the following steps:

[0032] (A) Treating a refinery soapstock with a strong alkaline base in the presence of an alcohol, such as ethanol or methanol. The saponification of the triglycerides present in the refinery soapstock is achieved by treating the soapstock with a strong alkaline base, such as, but not limited to, sodium hydroxide or potassium hydroxide. This treatment can be conducted under heating and alcohol reflux. Substantial triglycerides present are saponified by the strong alkaline base.

[0033] (B) After finishing the reaction described in (A), the product is filtered to remove substantially insoluble organic material. This organic material comprises polypeptides and lecithin and can be used as an emulsifying agent in industrial applications or as an additive to animal feed.

[0034] (C) A strong mineral acid, such as, but not limited to, sulfuric, phosphoric, or chloride acid is then added to the alcoholic solution. The mixture is then heated to around the boiling point of the alcohol and refluxed. Fatty acids can form from the respective soaps.

[0035] (D) In the reaction described above, a mineral salt is formed between the strong alkaline base component of the soap and the strong mineral acid added. The salt is not soluble or sparingly soluble in an alcoholic medium, where the process is conducted. Accordingly, filtration and removal of the salt from the reactive medium is easy to perform. Generally, the filtered salt is a technical grade and can be sold for industrial applications. In an embodiment, technical grade sodium sulfate is obtained.

[0036] (E) After filtering the salt, the material is heated under reflux for esterification of the free fatty acids with the alcohol already being used.

[0037] (F) After esterification, a certain quantity of base, such as calcium oxide, calcium hydroxide, or sodium carbonate, is added to neutralize the excess mineral acid in the alcoholic solution.

[0038] (G) After neutralization, the solution is filtered again to remove the calcium or sodium salts formed during the neutralization.
The clear solution of methyl or ethyl esters in alcohol is ready for the removal of the excess of alcohol. This removal can be done by distillation of the methanol or ethanol at temperatures varying from 40° C. to 90° C., at ambient or at reduced pressure (vacuum).

After recovering the excess alcohol, the methyl or ethyl esters are centrifuged to eliminate the insoluble impurities.

The methyl or ethyl ester obtained in the centrifugation process is then distilled under vacuum for purification resulting in biodiesel.

Soapstock utilizes soapstock as a starting material. Soapstock refers to a residual by-product from the production of edible oils and fats. In one embodiment, the refining soapstock can come from soy oil refining or any other vegetable or animal oil chemical refining processes, such as, but not limited to, rice oil, sunflower oil, coconut oil, castor oil, chicken oil, cottonseed oil, corn oil, peanut oil, palm oil, and babassu oil. Preferably, soapstock is derived from oil selected from the group consisting of soy oil, palm oil, sunflower oil, and rice oil.

Soapstock water content will vary from process to process. A soapstock frequently comprises about 40-80% moisture content, including about 60-70% moisture content.

In one embodiment, the process is performed in an alcoholic medium. Any alcohol can be used such that the resulting biodiesel comply with specifications for the biodiesel. Preferred alcohols include methanol and ethanol. Other alcohols include propanol, butanol, hexanol, and heptanol.

The preferred process is performed in an alcoholic medium and produces hardly any residual water besides that already contained in the vegetable oil refinery soapstock. Any residual water is substantially free of inorganic salts and has almost no organic contamination. Therefore, treatment of the water becomes quite simple, and the usual water treatment systems can make its reuse efficient and applicable. Thus, the energy balance resulting from this process is positive, for the energy cost to produce biodiesel resulting from the preferred process is less than the energy generated by it. Accordingly, the present process turns the production of biodiesel from refinery soapstock into a feasible process from an economic and environmentally adequate point of view.

The saponification of soapstock in an alcoholic medium is facilitated with a strong alkaline base. A base that is soluble in the alcoholic medium is preferred. Preferred bases include, but are not limited to, sodium hydroxide and potassium hydroxide.

When the processes are performed in an alcoholic medium, certain resulting byproducts are insoluble. Such byproducts may be filtered from the alcoholic medium. After the saponification of soapstock with the base, there may be substantially insoluble organic material. This organic material can comprise polypeptides and lecithin and can be used as an emulsifying agent in industrial applications or as an additive to animal feed.

The saponified soapstock comprises fatty acid salts (soaps). Addition of a strong mineral acid to the fatty acid salts can yield respective fatty acids. A preferred acid facilitates exchange of ions to yield the fatty acids. Preferred acids include, but are not limited to, sulfuric acid, phosphoric acid, and chloridric acid.

The exchange of ions between the fatty acid salts and strong mineral acid also yields a salt. The salt may not be soluble or may be sparingly soluble in the alcohol medium such that the salt can be removed from the alcohol medium easily. The recovered salt can be of technical grade. In certain cases, the recovered salt can be reused in industrial applications. In a certain embodiment, such as using a sodium cation containing base (e.g. NaOH) and sulfate anion containing acid (e.g. H₂SO₄) in the process, the salt is sodium sulfate.

After removal of the salt, the alcoholic medium containing the fatty acid is subjected to esterification conditions. The esterification is performed with the alcohol already present. Alternatively, the alcohol can be exchanged for another alcohol. Preferably, the esterification is performed under acidic conditions. In an embodiment, the acidic conditions result from excess mineral acid that reacted with the saponified soapstock. As stated above, preferred acids include, but are not limited to, sulfuric acid, phosphoric acid, and chloridric acid.

Esterification, the excess acid is neutralized with a base. Any base that can neutralize the excess acid can be used. The salt resulting from the neutralization may not be soluble or may be sparingly soluble in the alcohol medium such that the salt can be removed from the alcohol medium easily. Preferred bases include, but are not limited to, calcium oxide, calcium hydroxide, sodium carbonate, and sodium bicarbonate.

After neutralization and removal of salts, the alcoholic medium contains esters of fatty acids. Removal of the alcohol yields esters of fatty acids. Removal of the alcohol can be achieved through evaporation, such as distillation. Preferably, the distillation can be performed at temperatures sufficient to remove the alcohol. The distillation can be performed at ambient or reduced pressure. The boiling point of methanol is 64.5° C. The boiling point of ethanol is 78° C. Accordingly, if methanol or ethanol is used as the alcoholic medium, the distillation can be performed at temperatures ranging about 40° C. to about 90° C. at ambient pressure to remove the alcohol.

The distillation yields esters of fatty acids. Subsequent purification of the esters of fatty acids can include eliminate insoluble impurities. The insoluble impurities can be removed by a separation means, such as centrifugation or filtration. Preferably, the insoluble impurities are removed by centrifugation.

Subsequent purification of the esters of fatty acids also can include a distillation. Preferably, the distillation after removal of insoluble impurities is done under vacuum. The distillation after removal of insoluble impurities can yield valuable products, such as biodiesel and further products obtained from subsequent workup of the distillation residue. Preferably, the biodiesel complies with specifications.

Purification of Distillation Resultate

The distillation residue after obtaining biodiesel can be further worked-up to yield valuable products. One
such product is sterols. The remaining distillation residue after obtaining biodiesel is generally neutral and has an average of about 2 to about 20% sterol content. In another embodiment, the sterol content is about 5 to about 15%. In another embodiment, the sterol content is about 10%. Examples of some such sterols and methods for obtaining purified sterols are described in U.S. Pat. No. 6,846,941, which is incorporated herein by reference. Sterols can be used as a supplement in the diet of animals and humans as a means to lower cholesterol in the blood serum. There is also commercial interest in the use of sterols as emulsion stabilizers and/or viscosity modifiers, especially in cosmetic formulas. Soybean oil producers and soy-based sterol producers have interest in methods of obtaining sterols.

[0056] The distillation residue after obtaining biodiesel can be submitted to additional distillation conditions, such as those disclosed in U.S. Pat. No. 6,846,941, to obtain purified sterols. The sterols can be distilled directly in the thin film evaporation (TFE) under vacuum of about 30 to about 1 mbar and temperature of about 150° C. to about 210° C. or falling film evaporation (FFE) preferably under vacuum of about 1 x 10⁻¹ mbar and temperature of about 180° C. to about 220 or 230° C. to remove lighter volatiles. Then, on a subsequent distillation step, the residue can be distilled in a short-path distillation preferably under vacuum of about 1 x 10⁻¹ mbar or lower and at a temperature of about 220 or 230° C. to about 240 or 280° C. A concentrated sterol fraction containing about 40 to about 70% sterols can be obtained in some embodiments. The distilled sterols can be submitted to crystallization to produce purer sterols.

[0057] In some embodiments, the process can further comprise distilling or evaporating one or more compounds selected from the group consisting of lights, medium-lights, and water from the distillation residue prior to the distilling to separate at least a portion of the unsaponifiable compounds.

[0058] The process of purification of the distillation residue begins by providing the distillation residue after obtaining biodiesel, wherein the distillation residue can comprise one or more unsaponifiable compounds. The process further can continue by subjecting a mixture of one or more unsaponifiable compounds to a distillation to form a distillate comprising at least a portion of more pure unsaponifiable compounds.

[0059] In preferred embodiments, the process can further comprise subjecting the distillate comprising at least a portion of the unsaponifiable compounds to a subsequent distillation to form a second distillate and a second residue, thereby further purifying and/or separating the unsaponifiable compounds.

[0060] The methods disclosed herein comprise multiple steps. Which steps are used will vary depending on several factors, including, but not limited to, the identities of the starting material and desired target(s) and valuable product(s). For some materials, it is desired to perform one or more steps of pre-treatment with regard to cleaning up the material for further processing. Such cleaning methods include, but are not limited to, rinsing, washing, filtering, and decanting.

[0061] In an embodiment, the process is performed in an alcoholic medium, which generates sub-products from the contaminants with adequate quality to be marketed directly, representing an additional source of earnings for the production of biodiesel. Because the process is preferably performed in an alcoholic medium, insolubility of certain byproducts results. These insoluble byproducts can be easily separated. Separation is preferably by filtration. The sodium sulfate produced is easily separated from the rest of the process, and finds application in the industry generally as commercial grade sodium sulfate. The organic byproduct material containing materials, such as polypeptides and lecithin, is easily separated from the rest of the products and can be marketed as an industrial emulsifier or animal feed additive. The preferred process also yields other valuable products, such as sterols, from subsequent purification steps.

[0062] The following non-limiting examples illustrate additional embodiments of biodiesel (methyl or ethyl esters) production and separation from refining soapstock. The disclosure below is of specific examples setting forth preferred methods. These examples are not intended to limit the scope, but rather exemplify preferred embodiments.

EXAMPLE 1

[0063] About 1 kg of refinery soapstock, with 65% moisture content, obtained from refining soy oil, was dissolved in about 5 kg of ethyl alcohol and saponified under reflux, in the presence of about 40 g of sodium hydroxide solution/50% of concentration. The product was then heated at atmospheric pressure until the alcohol began to boil and reflux back to the reacting medium, at a temperature around 65° C. to 90° C. The reaction was performed for about 30 to 90 minutes, when substantial oil/triglycerides present in the refining soapstock were converted into sodium soap. The alcoholic solution was then filtered to separate the organic material, mainly composed of lecithin and gums that, under the conditions above, do not react and are not soluble; about 107.8 g of lecithin and gums were obtained. This organic contaminant is present as a crystalline material.

[0064] The filtered lecithin and gums were then dried.

[0065] The alcoholic solution was again heated under the same reflux conditions for another period of about 30 to 90 minutes, after the addition of about 240 g of concentrated sulfuric acid. During this period, the sulfuric acid reacted with the sodium soap to form fatty acids and sodium sulfate. Under the reacting conditions, sodium sulfate, which is not soluble, was filtered, producing 125 g of a white crystalline material.

[0066] After filtering sodium sulfate, the material was again heated under reflux to esterify the free fatty acids with the ethyl alcohol present. The reaction was performed for about 30 to 90 minutes. Excess sulfuric acid was neutralized by adding about 90 g calcium hydroxide. After the neutralization reaction of the free mineral acid, the material was filtered to remove the calcium salts formed. About 255.6 g calcium sulfate was produced.

[0067] The alcoholic solution obtained comprises a solution of ethyl esters of soy fatty acids in ethyl alcohol. The alcoholic solution was then heated to distill excess ethyl alcohol. The distillation was performed at temperatures around 75° C. to 90° C. and at pressures around 760 mmHg to 100 mmHg to yield ethyl alcohol and the ethyl ester biodiesel.
The ethyl ester was centrifuged to remove the insoluble contaminants and other precipitates; about 239.2 g of impurities were eliminated.

The clear ethyl ester obtained from the soy oil refinery soapstock was then distilled for final purification and to meet the international Biodiesel specifications. This distillation was performed in a distillation system under vacuum, at a temperature around 180° C. to 250° C. and a pressure varying from 3 mmHg to 760 mmHg. An ethyl ester from soy fatty acids was obtained; the analytical data of this product are found in Table 1 and the material meets the biodiesel specification established worldwide. 326 g of ethyl esters/Biodiesel were obtained.

EXAMPLE 2

About 1 kg of refinery soapstock, with 65% moisture content, obtained from refining soy oil, was diluted in about 5 kg of methyl alcohol and saponified under reflux, in the presence of about 40 g of sodium hydroxide solution/50% concentration. The product was then heated at atmospheric pressure until the point where the alcohol began to boil and reflux back to the reacting medium, at a temperature around 65° C. to 90° C. The reaction was performed for about 30 to 90 minutes, when substantial triglycerides present in the refining soapstock were converted into sodium soap. The alcoholic solution was then filtered to separate the organic material, mainly composed of lecithin and gums that, under the conditions above, did not react and are not soluble; about 109 g of lecithin and gums were obtained. This organic contaminant is present, after filtration, as a crystalline material.

The filtered lecithin and gums were then dried.

The alcoholic solution was heated under the same reflux conditions for another period of about 30 to 90 minutes, after the addition of 235 g of concentrated sulfuric acid. During this period, the sulfuric acid reacted with the sodium soap to form fatty acids and sodium sulfate. Under the reacting conditions, sodium sulfate, which is not soluble, was filtered, producing 120 g of a white crystalline material.

After filtering sodium sulfate, the material was again heated under reflux to esterify the free fatty acids with the ethyl alcohol present. The reaction was performed for about 30 to 90 minutes. Excess sulfuric acid was neutralized by adding about 90 g calcium hydroxide. After the neutralization reaction of the free mineral acid, the material was filtered to remove the calcium salts formed. About 250 g calcium sulfate was produced.

The alcoholic solution obtained comprises a solution of methyl esters of soy fatty acids in methyl alcohol. The alcoholic solution was then heated to distill excess methyl alcohol. The distillation was performed at temperatures around 75° C. to 90° C. and at pressures around 760 mmHg to 100 mmHg to yield methyl alcohol and the methyl ester/biodiesel.

The methyl ester was centrifuged to remove the insoluble contaminants and other precipitates; about 230 g of impurities were eliminated.

The clear methyl ester obtained from the soy oil refinery soapstock was then distilled for final purification and to meet the international Biodiesel specifications. This distillation was performed in a distillation system under vacuum, at a temperature around 60° C. to 100° C. and a pressure varying from 3 mmHg to 760 mmHg. A methyl ester from soy fatty acids was obtained; the analytical data of this product are found in Table 1 and the material meets the biodiesel specification established worldwide. 352 g of methyl esters/Biodiesel were obtained.

EXAMPLE 3

About 1 kg of refinery soapstock, with 65% moisture content, obtained from refining soy oil, was dissolved in about 5 kg of ethyl alcohol and saponified under reflux, in the presence of about 40 g of sodium hydroxide solution/50% of concentration. The product was then heated at atmospheric pressure until the alcohol began to boil and reflux back to the reacting medium, at a temperature around 65° C. to 90° C. The reaction was performed for about 30 to 90 minutes, when substantial oil/triglycerides present in the refining soapstock were converted into sodium soap. The alcoholic solution was then filtered to separate the organic material, mainly composed of lecithin and gums that, under the conditions above, do not react and are not soluble; about 109 g of lecithin and gums were obtained. This organic contaminant is present as a crystalline material.

The filtered lecithin and gums were then dried.

The alcoholic solution was again heated under the same reflux conditions for another period of about 30 to 90 minutes, after the addition of about 240 g of concentrated sulfuric acid. During this period, the sulfuric acid reacted with the sodium soap to form fatty acids and sodium sulfate. Under the reacting conditions, sodium sulfate, which is not soluble, was filtered, producing 125 g of a white crystalline material.

After filtering sodium sulfate, the material was again heated under reflux to esterify the free fatty acids with the ethyl alcohol present. The reaction was performed for about 30 to 90 minutes. Excess sulfuric acid was neutralized by adding about 90 g calcium hydroxide. After the neutralization reaction of the free mineral acid, the material was filtered to remove the calcium salts formed. About 250 g calcium sulfate was produced.

The alcoholic solution obtained comprises a solution of ester esters of soy fatty acids in ethyl alcohol. The alcoholic solution was then heated to distill excess ethyl alcohol. The distillation was performed at temperatures around 75° C. to 90° C. and at pressures around 760 mmHg to 100 mmHg to yield ethyl alcohol and the ethyl ester/biodiesel.

The ethyl ester was centrifuged to remove the insoluble contaminants and other precipitates; about 240 g of impurities were eliminated.

The clear ethyl ester obtained from the soy oil refinery soapstock was then distilled for final purification and to meet the international Biodiesel specifications. This distillation was performed in a distillation system under vacuum, at a temperature around 180° C. to 250° C. and a pressure varying from 3 mmHg to 760 mmHg. An ethyl ester from soy fatty acids was obtained; the analytical data of this product are found in Table 1 and the material meets the biodiesel specification established worldwide. 352 g of ethyl esters/Biodiesel were obtained.
[0084] Below, Table 1, that presents the parameter and conditions in which the examples described in this descriptive report were performed.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Methodology</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash point in closed vessel</td>
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<td>Water and sediments</td>
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<td>Cinematic viscosity at 40°C</td>
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<td>Sulfated ashes Corrosion to copper at 50°C</td>
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<td>Density 20/4°C</td>
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<td>Distillation under vacuum finish</td>
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</tr>
</tbody>
</table>

[0085] Many modifications and variations of the embodiments described herein may be made without departing from the scope, as is apparent to those skilled in the art. The specific embodiments described herein are offered by way of example only.

What is claimed is:

1. A process for producing biodiesel comprising:
   - saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock;
   - filtering the solution of saponified soapstock to remove substantially insoluble organic material;
   - adding a mineral acid to the filtered solution of saponified soapstock to form fatty acids and a mineral salt; and
   - esterifying the fatty acids, thereby forming biodiesel.
2. The process of claim 1, further comprising neutralizing excess mineral acid after addition of the mineral acid to the filtered solution.
3. The process of claim 2, further comprising removing salts formed from the neutralization.
4. The process of claim 1, further comprising removing the alcohol after esterification.
5. The process of claim 4, wherein the removal of alcohol is performed by distillation.
6. The process of claim 1, further comprising removing insoluble impurities after esterification.
7. The process of claim 6, wherein the removal of insoluble impurities is performed by centrifugation or filtration.
8. The process of claim 1, further comprising distilling the esters of fatty acids after esterification.
9. The process of claim 1, wherein the soapstock originated from refining of an oil selected from the group consisting of soy oil, rice oil, sunflower oil, coconut oil, castor oil, chicken oil, cottonseed oil, corn oil, peanut oil, palm oil, and babassu oil.
10. The process of claim 1, wherein the alcohol is methyl alcohol or ethyl alcohol.
11. The process of claim 1, wherein the alkaline base is sodium hydroxide or potassium hydroxide.
12. Biodiesel obtained from a process comprising:
   - saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock;
   - filtering the solution of saponified soapstock to remove substantially insoluble organic material;
   - adding a mineral acid to the filtered solution of saponified soapstock to form fatty acids and a mineral salt; and
   - esterifying the fatty acids.
13. Sterols obtained from a process comprising:
   - saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock;
   - filtering the solution of saponified soapstock to remove substantially insoluble organic material;
   - adding a mineral acid to the filtered solution of saponified soapstock to form fatty acids and a mineral salt; and
   - esterifying the fatty acids;
   - removing insoluble impurities after the esterification; and
   - distilling the solution of esters of fatty acids after esterification to obtain sterols.
14. The sterols of claim 13, wherein the distillation step is performed by thin film evaporation or falling film evaporation.
15. The sterols of claim 14, wherein the process further comprises short-path distilling the product of distillation of the solution of esters of fatty acids.
16. The sterols of claim 15, wherein the process further comprises crystallizing the product obtained by short-path distillation.
17. Organic material obtained from a process comprising:
   - saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock; and
   - filtering the solution of saponified soapstock to obtain substantially insoluble organic material.
18. Mineral salts obtained from a process comprising:
   - saponifying a soapstock with an alkaline base in an alcohol to yield a saponified soapstock;
   - filtering the solution of saponified soapstock to remove substantially insoluble organic material;
   - adding a mineral acid to the filtered solution of saponified soapstock to form fatty acids and a mineral salt; and
   - separating the mineral salt from the solution.

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