A process for the treatment of sugar cane filter cake mud separates and extracts the mud’s components into useful materials. The materials include fiber, lignin, beta-carotene, oil containing a high content of phytosterols, and refined wax. The fiber can be used as an animal feed or a source of energy, the refined wax is a resource of polycosanol and other established purposes, and resin can be used as an additive in asphalt mixtures and tire manufacturing or can be recycled back into the sugar milling process. The process is self-contained, requiring the input only of fresh water and chemical additives to adjust pH and coloration.
FIG. 1
METHOD FOR PROCESSING SUGAR CANE FILTER CAKE MUD AND EXTRACTING COMPONENT PRODUCTS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a National Stage of International Application No. PCT/US2006/01904 filed Jan. 20, 2006 (which was published in English), which claims priority to U.S. application Ser. No. 11/040,315 filed Jan. 21, 2005, each of which is hereby incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] This application presents a process for the treatment of sugar cane filter cake mud that separates and extracts its components into usable products. It allows for the efficient elimination of a voluminous amount of waste material of the sugar industry and can be undertaken with relatively low energy consumption and reduced capital and operating investments as compared to existing technologies that employ organic solvents to produce only a crude wax.

[0003] For many years, efforts have been made to find practical uses for the byproducts of processed sugar cane. Chief among these is sugar cane filter cake mud. The mud is an abundant material, representing between 3-4% of the total crushed sugar cane. It is also a very attractive material for exploitation as it possesses a wide and diverse range of materials and elements (more than 50 have been identified). However, this complexity also complicates effective treatment of the mud. Indeed untreated mud ferments within days, and the decay of its components commences at that time.

[0004] The sugar industry currently treats the vast bulk of this mud as a waste product thereby incurring handling costs that vary according to the prevailing government environmental regulations. Typically, a portion of the mud is used as a fertilizer within a few miles of the facility that generated the mud. Such use is limited by the costs of transporting the mud and the capacity of soils to accept it. The balance of the mud is usually contained in some sort of closed system such as an oxidation lagoon where it is mixed with water, allowed to decompose and then transported for disposal. These closed systems divert lands from other uses and incur significant maintenance costs.

[0005] Policosanol, which is a second generation mud derivative, is one of the useful by-products of sugar cane processing, and is, itself, a valuable substance having a number of beneficial uses. The principal impediment to the widespread use of policosanol, however, is the extremely high cost of producing it. However, by using this refined wax, it is possible to considerably reduce the cost of producing policosanol. Accordingly, the refined wax provided by embodiments of the process disclosed herein can be an attractive starting material for the production of policosanol and phytosterols by standard processes.

SUMMARY OF THE INVENTION

[0006] This process of this invention eliminates the need for current treatment and disposal practices. In its broadest application the invention can be illustrated by way of a facility that warehouses and processes all the available mud generated in a sugar cane cultivation zone. Alternatively the process can be established on a smaller scale, including processing the mud at the site of a sugar mill or other location. The process of this invention effectively closes the industrial cycle of sugar cane production by taking the primary sugar cane by-product for which no practical use has been established and treating it in such a way that substantially all component parts are inexpensively separated and may then be applied to other uses. These component parts are thereby made available for immediate as well as secondary exploitations, and no wastes need remain at conclusion of the process. Additionally the process can be readily modified to extract other sub-components as uses for these are identified.

[0007] According to the various embodiments of this invention, sugar cane wax in the form of an aqueous emulsion, substantially free of fiber, resin and oil can be obtained by contacting sugar cane mud with a liquid extractant to form a mixture of the extractant, sugar cane wax, fiber, resin and an oil; emulsifying the sugar cane wax in the extractant to provide a mixture containing solids suspended in the liquid phase or emulsion; and clarifying the liquid phase by extracting the solids. The solids contained in the emulsion prior to extraction include the fiber, the resin and the oil; absorbed on the resin. A preferred extractant is water. Additional processing steps, as described below, provide sugar cane wax in a substantially pure dry state.

[0008] A preferred process delivers the mud sequentially to a series of extractors in each of which the mud is hydrated, heated, and agitated. The resulting mixture is transported from one extractor to another via a series of pipes, each having an internal rotary worm-screw to move the mixture to the next extractor. The screw feeder pipes also have perforations in their lower portions to allow gravity to separate and remove liquids that are released from the mixture during transport. Each of the liquids is collected, retained, and reused during one of the treatment processes. At one stage, the separation of the mixture is induced by placing it in a centrifuge, which causes the separation of resins and waxes. Through the process of this invention, each major component of the mud can be extracted and thereafter used for other purposes.

[0009] It is an object of this invention to provide a process whereby sugar cane filter cake mud can be separated into usable components. It is a further object of this invention to provide a method whereby usable components of sugar cane filter cake mud can be extracted. It is yet a further object of the invention to provide a process for disposing of otherwise unusable byproducts of sugar cane processing, and in particular for disposing of sugar cane filter cake mud. These and other objects of the invention will become apparent through the following description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a graphical depiction of an embodiment of the process of this invention for treating sugar cane filter cake mud to extract usable components.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] The treatment and processing of sugar cane results in waste byproducts that include a substantial amount of sugar cane filter cake mud. FIG. 1 shows the steps of one embodiment of this invention that a mud processing facility can utilize in the processing of this byproduct. Mud can be delivered to the facility by sugar mills and processors either by track or by way of a slurry to an open air patio.
be stored pending processing. During its storage in the patio, the mud is maintained in a moist state by continuously sprinkling it with recycled runoff water from the patio that is captured and collected in a first collector 20 for delivery to a sprinkler system 30 by means of pipes 25. A number of shut-off valves are used throughout the process to control the volume of liquid being transported. Valve 35 is typical of all shut-off valves used in the process. The use of recycled water retards or prevents fermentation and decay of the unprocessed mud.

[0012] The water used for sprinkling the unprocessed mud is similar to "pool water," in that it has an almost neutral pH with a low chlorine content (less than about 0.6 measure with an indicator of n-toluidine), which inhibits the mud’s fermentation. To facilitate the draining and recycling of this water, a preferred patio is designed with a 1.5% slope with collecting canals in the inferior lateral. This establishes a closed water circuit for the process. In the event that additional water is needed for sprinkling, it may be supplied from water collector tank 180 that also supplies water for second extractor 70 during the process. Excess water from the patio may also be supplied to second extractor 70, as conditions may require.

[0013] Processing begins when the mud is fed into a screw feeder 40 which transports it under pressure to a first extractor 50. Mud can be delivered to screw feeder 40 by means of a conveyor belt (not shown), or any other suitable means for ensuring a supply of mud for the process. Screw feeder 40 is able to maintain a constant flow of mud to first extractor 50. Screw feeder 40 delivers the mud near the bottom of extractor 50, where the mud is mixed with a second stage liquid extract (“Extract II”) that has been collected later in the process at third collector 85 and transported back to first extractor 50 through pipe 55. Extract II is introduced into first extractor 50 at a ratio to the incoming mud of about 1:1 by volume. From time to time, sludge and other residue may be removed from first extractor 50 through cleaning and drainage pipes 45 whose use is controlled by a shut-off valve.

[0014] First extractor 50 is a scvle tank where the mixture is subjected to variable agitation (about 30-60 rpm) and heating with steam at about 10-bar pressure to about 85-90°C. This mix flows continuously such that sand and other heavy impurities are permitted to settle to the bottom of extractor 50 where they may be removed through drainage pipe 45. Otherwise, the mixture exits extractor 50 through an overflow tube located near its top, and is transported via a second screw feeder 60 to second extractor 70. Screw feeder 60 has perforations in the bottom of the pipe of approximately 0.5 mm for draining a first stage liquid extract (“Extract I”) from the mixture where it is collected in second collector 65. The perforations in screw feeder 60 and the additional screw feeders utilized herein are sufficiently small to retain the bulk of the fiber contained in the mixture being transported. Screw feeder 60 transports the solid phase (a moist fibrous mud) to second extractor 70 while Extract I, which is a liquid containing wax emulsion, oil, resin and other components, falls through the perforations in screw conveyor 60 where it enters collector 65 and is deposited into static decanter tank 90 where remaining sand and other heavy impurities may settle.

[0015] The solid phase of the mixture from screw feeder 60 is continuously fed into a second extractor 70 that can be identical to first extractor 50, and where the process described for first extractor 50 above is repeated. Here, however, recycled water from collector tank 180, rather than Extract II, is fed into second extractor 70 in a 1:1 ratio by volume. The recycled water from collector tank 180 contains lignin that promotes the emulsification of the wax. The high temperature and agitation also exercise a positive effect on the emulsification process. When the mixture exits second extractor 70, it is transported via screw feeder 80 having a perforated bottom (0.5 mm). Screw feeder 80 can be longer than screw feeders 40 and 60, has perforations sufficiently small to retain the bulk of the fiber and transports the fiber to a collection area 95 where it can be prepared for animal feed or fuel, or is otherwise disposed of. The liquid (“Extract II”) that drains from the perforated base of screw feeder 80 is then transported back to first extractor 50 where it is mixed with the mud entering the first extractor 50.

[0016] The mud used in the two stage extraction process system is rich in lignin (and may include some lignosulfonates) that is soluble in water and has a high emulsification power that emulsifies waxes. The extraction process utilized herein requires minimal equipment and uses the mud's own constituent elements to both form an emulsion and to partition materials in one phase or another. Additionally, the extraction phase has the advantage of not requiring organic solvents. In mixing any organic solvent with a fibrous and diverse material such as the mud process by this invention, there is an inevitable and increasing loss of the solvent, and elevated energy consumption for its recuperation, since the solvent is occluded inside the parenchymatous tissue (sponge-like aspects) that is abundant in the mud. This factor may account for the scarce industrialization of the mud under existing technologies based on solvent extractions.

[0017] The primary result of the extraction phase is the creation and collection of Extract I, which is initially collected in static decanter tank 90. After being collected, Extract I is pumped from static decanter tank 90 to decanter centrifuge 100, which is operated at about 70-75°C and produces up to about 2800 G to completely separate resin from the remainder of extract I. The resin emerges from the decanter centrifuge as a solid with 75-80% humidity and with the majority of the oils that were present in extract I. This resin is transported via pipe 105 to a collection area 110 where sugar cane oil can be extracted through means well known in the art. The liquid produced by decanter centrifuge 100, “Extract III,” is an emulsion consisting principally of waxes, lignin emulsified and beta-carotene. Critically, unlike the crude sugar cane wax that is produced under current technology, Extract III is almost completely free of oil.

[0018] To extract oils from the resin 110, the resin is treated with an organic solvent (i.e. a hydrocarbon such as hexane) in an extractor (not shown) that is similar to those used to produce the resin. The resin, after the extraction process is completed, may be separated by simple sedimentation, and the solvent is recovered by evaporation. This extract may be filtered to separate small resin particles and some remaining wax, and the solvent is recovered by evaporation. The sugar cane oil obtained in this manner can be used for different proposes such as animal feed or phytosterols extraction (a second generation mud derivative). Sugar cane oil is rich in phytosterols (free and associated) which are increasing recognized as agents for lowering blood cholesterol levels. These phytosterols can be recovered and added to foods or utilized as nutritional supplements. Sugar cane oil is a resource not currently used for this purpose, probably because the high costs of current technologies. However, the process of this invention reduces the cost of producing oil
from the resin and makes the further processing of the resin cost-effective. The treated resin can be used as an additive in asphalt or tire manufacturing.

[0019] As noted above, decanter centrifuge 100 pumps extract III to static decanter tank 120, which will hold the extract III for approximately six hours. Static decanter tank 120 is operates continuously and is used to provide additional clarification to extract III. Residual particles of resin, small remnant fibers, lignin and beta-carotene are separated in static decanter tank 120 and introduced via line 115 into line 155 which provides liquid from water collector tank 180 to second extractor 70 and storage patio 10.

[0020] The resulting wax emulsion remaining in static decanter tank 120 has a solids concentration of about 3-4%. In that state, this emulsion can be pumped via line 125 to a collection facility 130 where it can be used to treat fruits without further processing. Alternatively, leaving static decanter tank 120, the wax emulsion may be pumped via lines 125 and 135 to a continuous mixer 140 where the pH is adjusted to a value of about 8.5 with NaOH, and lye can added to decolorize lignin and other possible colorants. This mixture also initiates the breaking of the wax emulsion, causing it to separate as it flows into sedimentation tanks 150 through lines 145. The sedimentation tanks 150 are continuously filled, and wax commences to separate immediately. The neutral pH improves sedimentation. The required volumes of lye are small, and are adjusted by volume depending on the lye concentration being used.

[0021] Once filled with the wax emulsion, the sedimentation tanks 150 allow the emulsion to stand still for four up to about (4) hours to permit the wax to form sediments. Once the desired sedimentation of wax is achieved, the clarified, wax free, liquid is removed via lines 185 and sent to a collector tank 180 through line 190 where it is mixed with clean, fresh water 170 and is treated to achieve a neutral pH and chlorine content as such has been previously discussed. Collector tank 180 is one source of water that can be recycled via line 155 to moisten the mud stored in the patio 10 and that is used to mix with the mud in extraction tank 70. The liquid in collector tank 180 is also a rich source of lignin and beta-carotene which have health care applications including treatment of arthritis and cystic fibrosis and dietary supplements. Accordingly, if desired, these materials can be extracted from the unwashed clarified wax, the clarified liquid, or a residue obtained from the clarified liquid and obtained free of liquid through vacuum evaporation. Solvents suitable for dissolving and/or extracting lignin and beta-carotene are well known to those skilled in the art.

[0022] The remaining wax is washed whereby clean water heated to about 60°C in heater 160 is fed to the sedimentation tanks 150 through line 165. Within sedimentation tanks 150, the water and wax are re-circulated via line 175 for about 30 minutes. The wax is then allowed to settle for a second time and the clarified liquid is removed and sent to collection tank 180 via lines 185 and 190. A second wash is accomplished by repeating the steps of introducing fresh, heated water into the sedimentation tanks 150 and re-circulating the mixture for about 30 minutes. Following the second wash, the wax can be transported through line 205 to a mechanical separator 200 operating at a temperature of about 15-20°C that may be a vacuum filter or a centrifuge. Any standing water is eliminated by vacuum evaporation. The wax is then transported through line 215 to dryer 210, then to a collecting facility 220.

[0023] Wax refined in this way (i.e. freed of oil and resin) has a high ester content and a clear yellow color. Due to its high purity, sugar cane wax refined according to the process of this invention is an excellent base or starting material for the production of policosanol.

[0024] The present invention contemplates modifications as would occur to those skilled in the art. It is also contemplated that processes embodied in the present invention can be altered, rearranged, substituted, deleted, duplicated, combined, or added to other processes as would occur to those skilled in the art without departing from the spirit of the present invention. In addition, the various stages, steps, procedures, techniques, phases, and operations within these processes may be altered, rearranged, substituted, deleted, duplicated, or combined as would occur to those skilled in the art.

[0025] Further, any theory of operation, proof, or finding stated herein is meant to further enhance understanding of the present invention and is not intended to make the scope of the present invention dependent upon such theory, proof, or finding.

What is claimed is:
1. A method for separating sugar cane wax and other useful components from sugar cane mud comprising:
(a) contacting the sugar cane mud with a liquid extractant to form a mixture comprising the extractant, the sugar cane wax, a fiber, a resin and an oil;
(b) emulsifying the sugar cane wax to provide a liquid phase comprising the sugar cane wax and the extractant, the liquid phase having suspended therein the fiber, the resin, and the oil, wherein the oil is associated with the resin;
(c) clarifying the liquid phase by extracting the fiber, the resin and the oil therefrom to provide an emulsion comprising sugar cane wax and extractant substantially free of fiber, resin and oil.
2. The method of claim 1, wherein the liquid extractant is water.
3. The method of claim 2, wherein the mixture additionally comprises a lignin and emulsifying comprises the steps of heating and agitating the mixture.
4. The method of claim 3, wherein the mixture is heated to at least about 85°C.
5. The method of claim 4, wherein extracting the fiber comprises the step of draining the liquid phase through a perforated surface having perforations sufficiently small to retain the fiber and form a first extract.
6. The method of claim 5, wherein extracting the resin and the oil comprises the step of centrifuging the first extract to provide an emulsion comprising sugar cane wax and water substantially free of the resin and the oil.
7. The method of claim 6, wherein centrifuging additionally provides a solid comprising the resin and the oil.
8. The method of claim 7, wherein the oil is extracted from the resin by contacting the resin with an organic solvent.
9. The method of claim 8, wherein the organic solvent is a hydrocarbon.
10. The method of claim 9, wherein the oil contains phytosterols and the method additionally comprises extracting the phytosterols from the oil.
11. The method of claim 6, wherein the method additionally comprises the step of breaking the emulsion and causing the wax to separate from the liquid phase and form a slurry.
12. The method of claim 11, wherein breaking the emulsion involves adding sufficient base to the emulsion to raise its pH to about 8.5.

13. The method of claim 11, additionally comprising separating the wax from the slurry to provide a clarified liquid and a moist wax, washing the wax with at least one fresh water wash and isolating the wax.

14. The method of claim 13, wherein isolating the wax comprises filtering the wax.

15. The method of claim 13, wherein isolating the wax comprises centrifuging the wax.

16. The method of claim 13, wherein the method additionally comprises drying the wax.

17. The method of claim 13, wherein the clarified liquid comprises an aqueous solution of lignin and the method further comprises isolating the lignin from the clarified liquid.

18. The method of claim 17, wherein isolating the lignin comprises extracting the lignin with a solvent.

19. The method of claim 13, wherein the clarified liquid comprises an aqueous solution of β-carotene and the method further comprises isolating the β-carotene from the clarified liquid.

20. The method of claim 19, wherein isolating the β-carotene comprises extracting the β-carotene with a solvent.

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