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(54) **METHODS FOR THE SYNTHESIS AND  
PURIFICATION OF DEOXYCHOLIC ACID**

**Publication Classification**

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(57) **ABSTRACT**

**Related U.S. Application Data**

(60) Provisional application No. 61/497,924, filed on Jun.  
16, 2011.

Synthesis and purification of deoxycholic acid and its salts  
are provided.

## METHODS FOR THE SYNTHESIS AND PURIFICATION OF DEOXYCHOLIC ACID

### CROSS REFERENCE TO RELATED APPLICATION

**[0001]** This application claims the benefit under 35 U.S.C. 119(e) of U.S. Provisional Application Ser. No. 61/497,924 filed Jun. 16, 2011, which is hereby incorporated by reference into this application in its entirety.

### BACKGROUND OF THE INVENTION

**[0002]** 1. Field of the Invention

**[0003]** This invention is directed to the synthesis of deoxycholic acid and salts thereof as well as to intermediates useful in the synthesis of deoxycholic acid. This invention still further provides purified deoxycholic acid compositions and methods for purification wherein the deoxycholic acid has a purity of at least 99%.

**[0004]** 2. State of the Art

**[0005]** Rapid removal of body fat is an age-old ideal, and many substances have been claimed to accomplish such results, although few have shown results. "Mesotherapy", or the use of injectables for the removal of fat, is not widely accepted among medical practitioners due to safety and efficacy concerns, although homeopathic and cosmetic claims have been made since the 1950's. Mesotherapy was originally conceived in Europe as a method of utilizing cutaneous injections containing a mixture of compounds for the treatment of local medical and cosmetic conditions. Although mesotherapy was traditionally employed for pain relief, its cosmetic applications, particularly fat and cellulite removal, have recently received attention in the United States. One such reported treatment for localized fat reduction, which was popularized in Brazil and uses injections of phosphatidylcholine, has been erroneously considered synonymous with mesotherapy. Despite its attraction as a purported "fat-dissolving" injection, there is little safety and efficacy data of these cosmetic treatments. See, Rotunda, A. M. and M. Kolodney, *Dermatologic Surgery* 32: 465-480 (2006) ("Mesotherapy and Phosphatidylcholine Injections: Historical Clarification and Review").

**[0006]** Recently published literature reports that the bile acid, deoxycholic acid, and salts thereof, have fat removing properties when injected into fatty deposits in vivo. See, WO 2005/117900 and WO 2005/112942, as well as US2005/0261258; US2005/0267080; US2006/127468; and US20060154906, all incorporated herein by reference in their entirety). Deoxycholate injected into fat tissue degrades fat cells via a cytolytic mechanism. Because deoxycholate injected into fat is rapidly inactivated by exposure to protein and then rapidly returns to the intestinal contents, its effects are spatially contained. As a result of this attenuation effect that confers clinical safety, fat removal therapies typically require 4-6 sessions. This localized fat removal without the need for surgery is beneficial not only for therapeutic treatment relating to pathological localized fat deposits (e.g., dyslipidemias incident to medical intervention in the treatment of HIV), but also for cosmetic fat removal without the attendant risk inherent in surgery (e.g., liposuction). See, Rotunda et al., *Dermatol. Surgery* 30: 1001-1008 (2004) ("Detergent effects of sodium deoxycholate are a major feature of an injectable phosphatidylcholine formulation used for localized fat dissolution") and Rotunda et al., *J. Am. Acad. Dermatol.* (2005:

973-978) ("Lipomas treated with subcutaneous deoxycholate injections"), both incorporated herein by reference in their entirety.

**[0007]** In addition, many important steroids have a 12- $\alpha$ -hydroxy-substituent on the C-ring of the steroid. Such compounds include, by way of example, bile acids such as deoxycholic acid, cholic acid, lithocholic acid, and the like. Heretofore, such compounds were typically recovered from bovine and ovine sources which provided a ready source of bile acids on a cost effective basis. However, with the recent discovery that pathogens such as prions can contaminate such sources, alternative methods for the synthesis of bile acids from plant sources or synthetic starting materials have become increasingly important. For example, deoxycholic acid from animals in New Zealand are a source of bile acids for human use under US regulatory regimes, as long as the animals continue to remain isolated and otherwise free of observable pathogens. Such stringent conditions impose a limitation on the amount of suitable mammalian sourced bile acids and does not preclude the possibility that the bile acid will be free of such pathogens.

**[0008]** There remains a need for suitable quantities of efficacious bile acids such as deoxycholic acid that are known from the outset to be free from moieties of animal origin (or pathogenic moieties capable of acting in an animal, particularly a mammal, and for human use, having a deleterious effect on a human), and other harmful agents such as animal or microbial metabolites, toxins, including bacterial toxins, such as pyrogens, for use as medicaments in humans.

**[0009]** In addition, there is a need to prepare a bile acid composition free of other unintended bile acids. In this regard, it is known that mammalian sourced deoxycholic acid is contaminated with cholic acid. In turn, it is further known that cholic acid is an essential component in the formation of gall stones. Accordingly, there is an ongoing need to provide methods for preparing and purifying deoxycholic acid which methods would not result in contamination with other bile acids.

### SUMMARY OF THE INVENTION

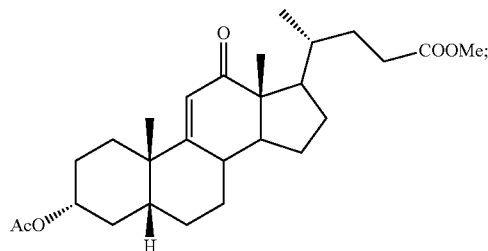
**[0010]** In one embodiment of this invention, there is provided a method for purifying crude deoxycholic acid or a salt thereof which method comprises:

**[0011]** i) a first recrystallization of the crude deoxycholic acid or a salt thereof from a  $C_{1-3}$  alcohol in methylene chloride to provide a product; and

**[0012]** ii) a second recrystallization of the product of step i) from a mixture of deionized water and a  $C_{1-3}$  alcohol to provide pure deoxycholic acid or a salt thereof.

**[0013]** In another embodiment of this invention, there is provided a method for preparing pure deoxycholic acid or a salt thereof which method comprises:

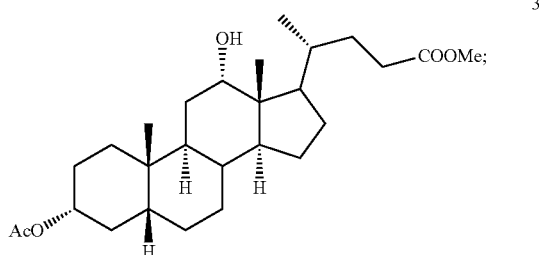
**[0014]** a) contacting compound 1







[0050] b) reacting compound 2 with lithium tri-*t*-alkoxy-aluminum hydride under reducing conditions to provide compound 3:



[0051] c) exposing compound 3 to deprotection and hydrolysis conditions to form crude deoxycholic acid or a salt thereof; and

[0052] d). purifying crude deoxycholic acid or a salt thereof by a method comprising:

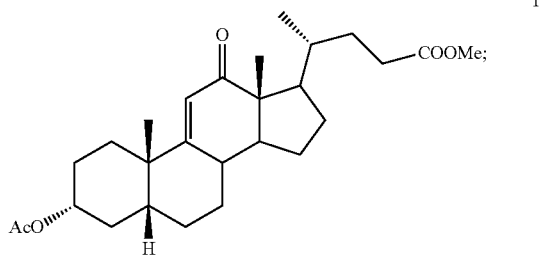
[0053] i) a first recrystallization of the crude deoxycholic acid or a salt thereof from a C<sub>1-3</sub> alcohol in methylene chloride; and

[0054] ii) a second recrystallization of the product of step i) from a mixture of deionized water and a C<sub>1-3</sub> alcohol to provide pure deoxycholic acid or a salt thereof.

[0055] In another embodiment, the C<sub>1-3</sub> alcohol in step d)i) comprises methanol. In another embodiment, the C<sub>1-3</sub> alcohol in step d)ii) comprises ethanol. In another embodiment, the C<sub>1-3</sub> alcohol in step d)i) comprises methanol and the C<sub>1-3</sub> alcohol in step d)ii) is comprises ethanol.

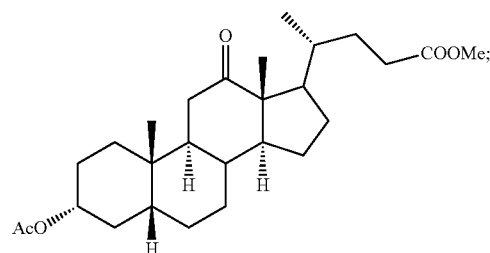
[0056] In another embodiment, this invention provides a method for preparing pure deoxycholic acid or a salt thereof which method comprises:

[0057] a) contacting compound 1



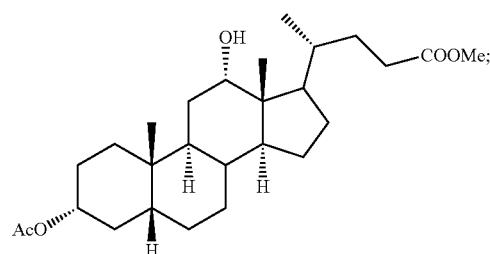
with hydrogen and Pd/C under hydrogenation conditions comprising hydrogen and Pd on carbon in an autoclave maintained at elevated pressure optionally followed by oxidizing any of the 12-hydroxyl groups formed during hydrogenation with pyridiniumchlorochromate under oxidizing conditions to provide compound 2;

2



[0058] b) reacting compound 2 with lithium tri-*t*-alkoxy-aluminum hydride under reducing conditions to provide compound 3:

3



[0059] c) exposing compound 3 to deprotection and hydrolysis conditions to form crude deoxycholic acid or a salt thereof; and

[0060] d). purifying crude deoxycholic acid or a salt thereof by a method comprising:

[0061] i) a first recrystallization of the crude deoxycholic acid or a salt thereof from 2 mol % methanol in methylene chloride at a temperature of about 35-37° C.; and

[0062] ii) a second recrystallization of the product of step i) from a mixture of a mixture of 10% deionized water in ethanol to provide pure deoxycholic acid or a salt thereof.

[0063] In one of its composition aspects, this invention is directed to compositions comprising deoxycholic acid or a salt thereof and a mixture of one or more C<sub>1-3</sub> alcohol(s) and methylene chloride. In one embodiment, the C<sub>1-3</sub> alcohol comprises methanol. In another embodiment, the C<sub>1-3</sub> alcohol comprises 1 mol %-5 mol % methanol. In another embodiment, the composition comprises 2 mol % methanol. In another embodiment, the invention comprises compositions, wherein said deoxycholic acid or a salt thereof is synthetic.

[0064] In another of its composition aspects, this invention is directed to compositions comprising synthetic deoxycholic acid or a salt thereof and a mixture of one or more C<sub>1-3</sub> alcohol(s) and deionized water. In one embodiment, the C<sub>1-3</sub> alcohol comprises ethanol. In another embodiment, the composition comprises a mixture of 5% deionized water in ethanol; alternatively 10% deionized water in ethanol; and alternatively 15% deionized water in ethanol. In another embodiment, the composition comprises a mixture of 10% deionized water in ethanol. In another embodiment, the invention comprises compositions, wherein said deoxycholic acid or a salt thereof is synthetic.

[0065] Subject matter similar to that disclosed herein is found in U.S. provisional application Ser. No. 61/288,132, filed on 18 Dec. 2009, U.S. provisional application Ser. No.

61/302,007 filed on 5 Feb. 2010, U.S. provisional application Ser. No. 61/303,816, filed on 12 Feb. 2010, and U.S. provisional application Ser. No. 61/348,686, filed on 26 May 2010, all of which are incorporated herein by reference in their entirety.

### EXAMPLES

**[0066]** In the examples below and elsewhere in the specification, the following abbreviations have the indicated meanings. If an abbreviation is not defined, it has its generally accepted meaning.

Ac	Acetyl
DCA	Deoxycholic acid
DCM (CH <sub>2</sub> Cl <sub>2</sub> )	Dichloromethane
ELSD	Evaporative light scattering detection
EtOH	Ethanol
EtOAc	Ethyl acetate
G	Grams
H or h	Hour
HCl	Hydrochloric acid
HPLC	High pressure liquid chromatography
Hz	Hertz
LiAl(O <sup>t</sup> Bu) <sub>3</sub> H	Lithium tri-tert-butoxyaluminum hydride
LOD	Loss on drying
Me	Methyl
MeOH	Methanol
MHz	Megahertz
Min	Minutes
mL	Milliliter
Mmol	Millimole
Mol	Mole
Na <sub>2</sub> SO <sub>4</sub>	Sodium sulfate
NaOH	Sodium hydroxide
NMT	Not more than
Pd/C	Palladium on carbon
PtO <sub>2</sub>	Platinum oxide
TFA	Trifluoroacetic acid
THF	Tetrahydrofuran
TLC	Thin layer chromatography
UV	Ultraviolet
Wt	Weight

**[0067]** General: All manipulations of oxygen- and moisture-sensitive materials were conducted with standard two-necked flame dried flasks under an argon or nitrogen atmosphere. Column chromatography was performed using silica gel (60-120 mesh). Analytical thin layer chromatography (TLC) was performed on Merck Kiesinger 60 F<sub>254</sub> (0.25 mm) plates. Visualization of spots was either by UV light (254 nm) or by charring with a solution of sulfuric acid (5%) and p-anisaldehyde (3%) in ethanol.

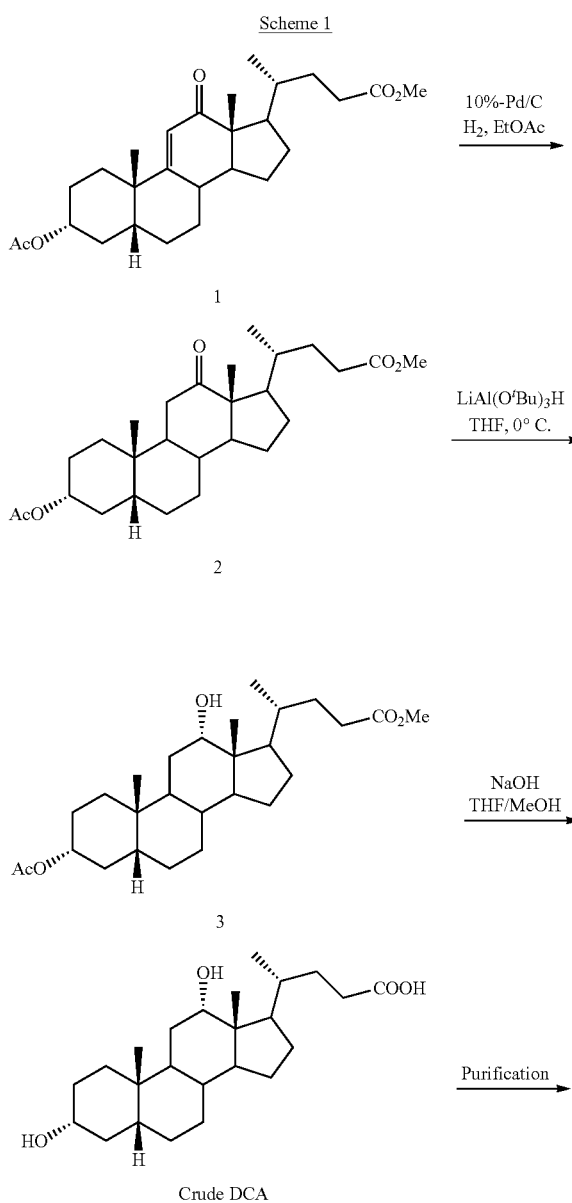
**[0068]** Apparatus: Proton and carbon-13 nuclear magnetic resonance spectra (<sup>1</sup>H NMR and <sup>13</sup>C NMR) were recorded on a Varian Mercury-Gemini 200 (<sup>1</sup>H NMR, 200 MHz; <sup>13</sup>C NMR, 50 MHz) or a Varian Mercury-Inova 500 (<sup>1</sup>H NMR, 500 MHz; <sup>13</sup>C NMR, 125 MHz) spectrometer with solvent resonances as the internal standards (<sup>1</sup>H NMR, CHCl<sub>3</sub> at 7.26 ppm or DMSO at 2.5 ppm and DMSO-H<sub>2</sub>O at 3.33 ppm; <sup>13</sup>C NMR, CDCl<sub>3</sub> at 77.0 ppm or DMSO at 39.5 ppm). <sup>1</sup>H NMR data are reported as follows: chemical shift (δ, ppm), multiplicity (s=singlet, d=doublet, t=triplet, q=quartet, br=broad, m=multiplet), coupling constants (Hz), and integration. Infrared spectra (FT-IR) were run on a JASCO-460+ model. Mass spectra were obtained with a Perkin Elmer API-2000 spectrometer using ES<sup>+</sup> mode. Melting points were determined using a LAB-INDIA melting point measuring apparatus and are uncorrected. HPLC chromatograms were

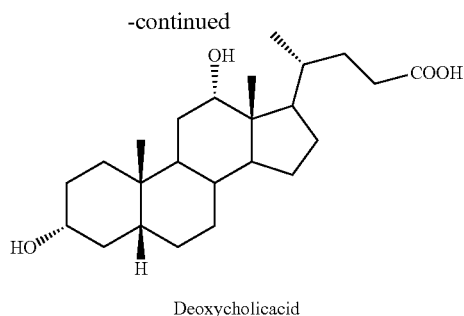
recorded using a SHIMADZU-2010 model with a PDA detector. Specific optical rotations were determined employing a JASCO-1020 at 589 nm and are uncorrected.

**[0069]** Chemicals: Unless otherwise noted, commercially available reagents were used without purification. Diethyl ether and THF were distilled from sodium/benzophenone. Laboratory grade anhydrous DMF, commercially available DCM, ethyl acetate and hexane were used.

### Example 1

**[0070]** In Scheme 1 below, there is provided a scheme for the synthesis and purification of deoxycholic acid from compound 1.





#### Conversion of Compound 1 to Compound 2:

**[0071]** The hydrogenation of compound 1 on 10.0 g scale using dry 10% Pd/C (15 wt %) in ethyl acetate (20 parts) was added and applied about 50 psi hydrogen pressure and temperature raised to 70° C. After reaching temperature 70° C., observed increase of hydrogen pressure to about 60 psi, at these conditions maintained for 60 h. After 60 hours 0.6% of compound 2 and 2.75% of allylic alcohol were still observed, so further stirred for additional 12 h (observed 0.16% of allylic alcohol and 0.05% of compound 2). After work-up, the reaction provided 9.5 g of residue.

**[0072]** Another hydrogenation reaction on 25 g of compound 1 with above conditions for 76 h provided 24.5 g of residue.

#### Method A

**[0073]** 10% Pd/C (900 mg) was added to a solution of compound 1 (2.0 g, 4.5 mmol) in EtOAc (150 mL) and the resulting slurry was hydrogenated in a Parr apparatus (50 psi) at 50° C. for 16 h. At this point the reaction was determined to be complete by TLC. The mixture was filtered through a small plug of Celite® and the solvent was removed under vacuum, providing compound 2 (1.6 g, 80% yield) as a white solid. TLC: p-anisaldehyde charring,  $R_f$  for 2=0.36.

TLC mobile phase: 20%—EtOAc in hexanes.

**[0074]**  $^1\text{H NMR}$  (500 MHz,  $\text{CDCl}_3$ ):  $\delta$ =4.67-4.71 (m, 1H), 3.66 (s, 3H), 2.45-2.50 (t,  $J$ =15 Hz, 2H), 2.22-2.40 (m, 1H), 2.01 (s, 3H), 1.69-1.96 (m, 9H), 1.55 (s, 4H), 1.25-1.50 (m, 8H), 1.07-1.19 (m, 2H), 1.01 (s, 6H), 0.84-0.85 (d,  $J$ =7.0 Hz, 3H).

**[0075]**  $^{13}\text{C NMR}$  (125 MHz,  $\text{CDCl}_3$ ):  $\delta$ =214.4, 174.5, 170.4, 73.6, 58.5, 57.4, 51.3, 46.4, 43.9, 41.2, 38.0, 35.6, 35.5, 35.2, 34.8, 32.0, 31.2, 30.4, 27.4, 26.8, 26.2, 25.9, 24.2, 22.6, 21.2, 18.5, 11.6.

**[0076]** Mass ( $m/z$ )=447.0 [ $M^+$ +1], 464.0 [ $M^+$ +18].

**[0077]** IR (KBr)=3445, 2953, 2868, 1731, 1698, 1257, 1029  $\text{cm}^{-1}$ .

**[0078]** m.p.=142.2-144.4° C. (from EtOAc/hexanes mixture).

**[0079]**  $[\alpha]_D^{25}$ =+92 ( $c$ =1% in  $\text{CHCl}_3$ ).

**[0080]** ELSD Purity: 96.6%; Retention time=9.93 (Inertsil ODS 3V, 250×4.6 mm, 5  $\mu\text{m}$ , ACN: 0.1% TFA in water (90:10))

#### Method B

**[0081]** A slurry of 10% Pd/C (9 g in 180 mL of ethyl acetate) was added to a solution of compound 1 (36 g, 81 mmol) in EtOAc (720 mL) and the resulting slurry was treated

with hydrogen gas (50 psi) at 45-50° C. for 16 h. (A total of 1080 mL of solvent may be used). At this point the reaction was determined to be complete by HPLC (NMT 1% of compound 1). The mixture was filtered through Celite® (10 g) and washed with ethyl acetate (900 mL). The filtrate was concentrated to 50% of its volume via vacuum distillation below 50° C. To the concentrated solution was added pyridinium chlorochromate (20.8 g) at 25-35° C. and the mixture was stirred for 2 h at 25-35° C., when the reaction completed by HPLC (allylic alcohol content is NMT 1%).

**[0082]** The following process can be conducted if compound 1 content is more than 5%. Filter the reaction mass through Celite® (10 g) and wash with ethyl acetate (360 mL). Wash the filtrate with water (3×460 mL) and then with saturated brine (360 mL). Dry the organic phase over sodium sulphate (180 g), filter and wash with ethyl acetate (180 mL). Concentrate the volume by 50% via vacuum distillation below 50° C. Transfer the solution to a clean and dry autoclave. Add slurry of 10% palladium on carbon (9 g in 180 mL of ethyl acetate). Pressurize to 50 psi with hydrogen and stir the reaction mixture at 45-50° C. for 16 h.

**[0083]** Upon complete consumption of compound 1 by HPLC (the content of compound 1 being NMT 1%), the reaction mixture was filtered through Celite® (10 g) and the cake was washed with ethyl acetate (900 mL). The solvent was concentrated to dryness via vacuum distillation below 50° C. Methanol (150 mL) was added and concentrated to dryness via vacuum distillation below 50° C. Methanol (72 mL) was added to the residue and the mixture was stirred for 15-20 min at 10-15° C., filtered and the cake was washed with methanol (36 mL). The white solid was dried in a hot air drier at 45-50° C. for 8 h to LOD being NMT 1% to provide compound 2 (30 g, 83.1% yield).

#### Conversion of Compound 2 to Compound 3:

##### Method A

**[0084]** A THF solution of lithium tri-tert-butoxyaluminum hydride (1 M, 22.4 mL, 22.4 mmol) was added drop wise to a solution of compound 2 (2.5 g, 5.6 mmol) in THF (25 mL) at ambient temperature. After stirring for an additional 4-5 h, the reaction was determined to be complete by TLC. The reaction was quenched by adding aqueous HCl (1 M, 10 mL) and the mixture was diluted with EtOAc (30 mL). The phases were separated and the organic phase was washed sequentially with water (15 mL) and saturated brine solution (10 mL). The organic phase was then dried over anhydrous  $\text{Na}_2\text{SO}_4$  (3 g) and filtered. The filtrate was concentrated under vacuum and the resulting solid was purified by column chromatography [29 mm (W)×500 mm (L), 60-120 mesh silica, 50 g], eluting with EtOAc/hexane (2:8) [5 mL fractions, monitored by TLC with p-anisaldehyde charring]. The fractions containing the product were combined and concentrated under vacuum to provide compound 3 (2.3 g, 91%) as a white solid.

TLC: p-anisaldehyde charring,  $R_f$  for 3=0.45 and  $R_f$  for 2=0.55.

TLC mobile phase: 30%—EtOAc in hexanes.

**[0085]**  $^1\text{H NMR}$  (500 MHz,  $\text{CDCl}_3$ ):  $\delta$ =4.68-4.73 (m, 1H), 3.98 (s, 1H), 3.66 (s, 3H), 2.34-2.40 (m, 1H), 2.21-2.26 (m, 1H), 2.01 (s, 3H), 1.75-1.89 (m, 6H), 1.39-1.68 (m, 16H), 1.00-1.38 (m, 3H), 0.96-0.97 (d,  $J$ =5.5 Hz, 3H), 0.93 (s, 3H), 0.68 (s, 3H).

**[0086]**  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ):  $\delta$ =174.5, 170.5, 74.1, 72.9, 51.3, 48.1, 47.2, 46.4, 41.7, 35.8, 34.9, 34.7, 34.0, 33.5, 32.0, 30.9, 30.8, 28.6, 27.3, 26.8, 26.3, 25.9, 23.4, 22.9, 21.3, 17.2, 12.6

**[0087]** Mass ( $m/z$ )=449.0 [ $\text{M}^+$ +1], 466.0 [ $\text{M}^+$ +18].

**[0088]** IR (KBr)=3621, 2938, 2866, 1742, 1730, 1262, 1162, 1041,  $\text{cm}^{-1}$ .

**[0089]**  $m.p$ =104.2-107.7° C. (from EtOAc).

**[0090]**  $[\alpha]_D^{25}$ =+56 ( $c$ =1% in  $\text{CHCl}_3$ ).

**[0091]** ELSD Purity: 97.0%; Retention time=12.75 (Inertsil ODS 3V, 250x4.6 mm, 5  $\mu\text{m}$ , ACN:Water (60:40)

#### Method B

**[0092]** A THF solution of lithium tri-tert-butoxyaluminum hydride (1 M, 107.6 mL, 107.6 mmol) was added over 1 h to a solution of compound 2 (30.0 g, 67 mmol) in dry THF (300 mL) at 0-5° C. After stirring for an additional 4 h at 5-10° C., the reaction was determined to be complete by HPLC (NMT 1% of compound 2). The reaction was cooled to 0-5° C. and quenched by adding 4N HCl (473 mL). The phases were separated. The aqueous layer was extracted with DCM (2x225 mL) and the combined organic phase was washed sequentially with water (300 mL) and saturated brine solution (300 mL). The organic phase was then concentrated to dryness by vacuum distillation below 50° C. Methanol (150 mL) was added to the residue and concentrated to dryness by vacuum distillation below 50° C. Water (450 mL) was then added to the residue and the mixture was stirred for 15-20 min., filtered and the cake was washed with water (240 mL). The white solid was dried in a hot air drier at 35-40° C. for 6 h to provide compound 3 (30 g, 99.6%).

#### Conversion of Compound 3 to Crude DCA:

**[0093]** To a solution of 3 in MeOH (4 vol) and THF (4 vol) was added a solution of NaOH (4.0 equiv) in DI water (5 M) maintaining the temperature below 20° C. HPLC analysis after 20 hours at 20-25° C. indicated <0.5% AUC of 3 and the two intermediates remained. The reaction was deemed complete, diluted with DI water (10 vol) and concentrated to ~10 volumes. The sample was azeotroped with 2-MeTHF (2x10 vol) and assayed by  $^1\text{H}$  NMR to indicate MeOH was no longer present. The rich aqueous phase was washed with 2-MeTHF (2x10 vol) and assayed by HPLC to indicate 0.3% AUC of the alcohol impurity remained. The aqueous phase was diluted with 2-MeTHF (10 vol) and adjusted to pH=1.7-2.0 using 2 M HCl (~4 vol). The phases were separated and the 2-MeTHF phase was washed with DI water (2x10 vol). The 2-MeTHF phase was filtered over Celite and the filter cake was washed with 2-MeTHF (2 vol). The 2-MeTHF filtrate was distilled to ~10 volumes and azeotroped with n-heptane containing Statsafe™ 5000 (3x10 vol) down to ~10 vol. The mixture was assayed by  $^1\text{H}$  NMR to indicate <5 mol % of 2-MeTHF remained relative to n-heptane. The slurry was held for a minimum of 2 hours at 20-25° C. and filtered. The filter cake was washed with n-heptane (2x10 vol) and conditioned under vacuum on the Nütsche filter with  $\text{N}_2$  for a minimum of 1 hour to afford DCA-crude as white solids. Purity=94.6% (by HPLC). HPLC analysis for DS-DCA (NMT 5% AUC).

#### Recrystallization of Deoxycholic Acid (DCA)

**[0094]** DCA-crude was diluted with 2 mol % MeOH in  $\text{CH}_2\text{Cl}_2$  (25 vol) and heated to 35-37° C. for 1 hour. The slurry was allowed to cool to 28-30° C. and filtered. The filter cake

was washed with  $\text{CH}_2\text{Cl}_2$  (5 vol) and dried under vacuum at 40° C. to afford DCA. HPLC analysis for DS-DCA (NMT 0.15% AUC).

**[0095]** DCA was dissolved in 10% DI water/EtOH (12 vol), polish filtered over Celite and washed with 10% DI water/EtOH (3 vol). The resulting 15 volume filtrate was added to DI water (30 vol) and a thin white slurry was afforded. The slurry was held for 24 hours, filtered, washed with DI water (20 vol) and dried under vacuum at 40° C. to afford pure DCA. OVI analysis for  $\text{CH}_2\text{Cl}_2$ , EtOH, n-heptane, MeOH and MeTHF was conducted to ensure each solvent was below ICH guideline. KF analysis conducted (NMT 2.0%). Purity=99.75% (by HPLC). Yield from DCA-crude=59%.

1. A method for purifying crude deoxycholic acid or a salt thereof, which method comprises:

- a first recrystallization of the crude deoxycholic acid or a salt thereof from a  $\text{C}_{1-3}$  alcohol in methylene chloride to provide a product; and
- a second recrystallization of the product of step i) from a mixture of deionized water and a  $\text{C}_{1-3}$  alcohol to provide pure deoxycholic acid or a salt thereof.

2. The method of claim 1, wherein the  $\text{C}_{1-3}$  alcohol in step i) comprises methanol.

3. The method of claim 1, wherein the  $\text{C}_{1-3}$  alcohol in step i) comprises 1 mol %-5 mol % methanol in methylene chloride.

4. The method of claim 3, wherein the  $\text{C}_{1-3}$  alcohol in step i) comprises 2 mol % methanol in methylene chloride.

5. The method of claim 1, wherein step i) further comprises a temperature of about 35-37° C.

6. The method of claim 1, wherein step i) comprises a first recrystallization from 2 mol % methanol in methylene chloride at a temperature of about 35-37° C.

7. The method of claim 1, wherein the  $\text{C}_{1-3}$  alcohol in step ii) comprises ethanol.

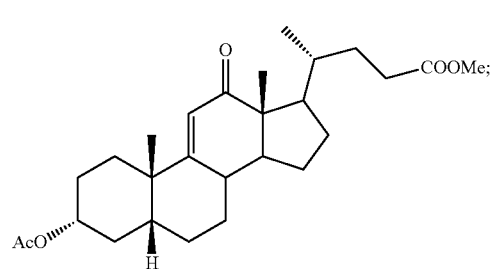
8. The method of claim 1, wherein step ii) comprises a second recrystallization from a mixture of 10% deionized water in ethanol.

9. The method of claim 1, wherein the method comprises:

- a first recrystallization of the crude deoxycholic acid or a salt thereof from 2 mol % methanol in methylene chloride at a temperature of about 35-37° C.; and
- a second recrystallization of the product of step i) from a mixture of a mixture of 10% deionized water in ethanol.

10. A method for preparing pure deoxycholic acid or a salt thereof which method comprises:

- contacting compound 1



with hydrogen and Pd/C under hydrogenation conditions comprising hydrogen and Pd on carbon in an autoclave maintained at elevated pressure optionally followed by oxidizing



