CLAIMS

1. A method for large scale conversion of a fatty alcohol into a fatty aldehyde, said method comprising the steps of:

a) providing a reaction mixture comprising at least 1 kilogram of fatty alcohol, a catalyst comprising a copper source, at least 1 kilogram of solvent, and a water absorbing or adsorbing material absorbing or adsorbing water, and

b) dissolving at least 0,01 µmol O_2 per minute per µmol copper in the reaction mixture or at least 0.001 µmol O_2 per minute per µmol initial fatty alcohol in the reaction mixture to the reaction mixture by feeding a gas or a liquid comprising O_2 into the reaction medium and thereby oxidizing more than 50 wt% of the fatty alcohol into fatty aldehyde and less than 50 wt% into fatty acid.

2. The method of claim 1 further comprising dissolving at least 0.049 µmol dissolved O_2 per minute per µmol copper in the reaction mixture.

3. The method of any preceding claim further comprising dissolving at least 0.0025 µmol dissolved O_2 per minute per µmol initial fatty alcohol in the reaction mixture.

4. The method of any preceding claim further comprising dissolving at least 0.025 µmol dissolved O_2 per minute per µmol fatty acid in the reaction mixture.

5. The method of any preceding claim comprising dissolving at least 10 µmol O_2, such as at least 20 µmol O_2, at least 40 µmol O_2, or at least 60 µmol O_2 per minute per gram of fatty alcohol to the reaction mixture, thereby obtaining the fatty aldehyde, optionally wherein the fatty alcohol and the fatty aldehyde are desaturated.

6. The method of any preceding claim, wherein the gas or a liquid comprising O_2 is air, optionally enriched with O_2.

7. The method of any preceding claim, wherein the feeding of gas or a liquid comprising O_2 into the reaction medium is made by pumping or bubbling a gas or liquid mixture comprising O_2 through the reaction mixture.

8. The method of any preceding claim, wherein the copper source comprises a copper (I) salt or a combination of copper (II) and a reductant.

9. The method of any preceding claim, wherein the catalyst further comprises a ligand such as a ligand selected from the group consisting of 2,2’-bipyridine, 4,4’-dimethyl-2,2’-bipyridine, 5,5'-dimethyl-2,2'-bipyridine 2,2'-bipyrimidine, 2,2’-bipyridine-4,4’-dicarboxylic acid or an ester thereof, 2,2’-bipyridine-5,5’-dicarboxylic acid or an ester thereof.

10.The method of any preceding claim, wherein the catalyst comprises an aminoxyl radical compound such as a aminoxyl radical compound selected from the group consisting of TEMPO, (4-hydroxy-2,2,6,6-tetramethylpiperidin-1-yl)oxyl (4-OH-TEMPO), 4-acetamido-TEMPO, 4-hydroxy-TEMPO benzoate, 4-amino-TEMPO, 2-azaadamantane-N-oxyl, 9-azabicyclo[3.3.1]nonane N-oxyl, 4-carboxy-TEMPO, 4-maleimido-TEMPO, 4-methoxy-TEMPO, 1-methyl-2-azaadamantane-N-oxyl, 4-oxo-TEMPO, and a polymer functionalised with any of said aminoxyl radical compounds.

11.The method of any preceding claim, wherein the catalyst comprises a base such as a base selected from the group consisting of 1-methylimidazole, 1,8-diazabicyclo[5.4.0]undec-7-ene, 1,5-diazabicyclo[4.3.0]non-5-ene, 1,5,7-triazabicyclo[4.4.0]dec-5-ene, 1,1,3,3-tetramethylguanidine, 7-methyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene, and potassium t-butoxide.

12.The method of any preceding claim, wherein the solvent is a non-halogenated solvent.

13.The method of claim 12, wherein the solvent is selected from acetonitrile, dimethyl sulfoxide (DMSO), dimethyl formamide (DMF), pentane, hexane, heptane, cycloalkane, petroleum ether, dioxane, diethyl ether, tetrahydrofuran, ethyl acetate, acetone, nitromethane, propylene carbonate, or a combination thereof.

14.The method of any preceding claim wherein the conversion of fatty alcohol to fatty aldehyde is at least 60 wt%, such as at least 80 wt%, such as at least 85 wt%, such as at least 87 wt%, such as at least 90 wt%, such as at least 95 wt%, such as at least 99 wt%.

15.The method of any preceding claim, wherein the ratio of fatty acid produced to fatty aldehyde produced is less than 10:90.

16.The method of any preceding claim, wherein the conversion of fatty alcohol to fatty acid is less than 40 wt%, such as less than 30 wt%, such as less than 20 wt%, such as less than 15 wt%, such as less than 10 wt%, such as less than 5 wt%, such as less than 1 wt%.

17.The method of any preceding claim wherein the water absorbing or adsorbing material is selected from molecular sieves, silica gels, aluminas, bentonite clays, calcium oxides, alkali metal carbonates, hydrogen carbonates, or alkali earth metal carbonates or a combination thereof.

18.The method of any preceding claim wherein the water absorbing or adsorbing material is added to the reaction medium in amounts, so that the water content in the reaction medium after the oxidation process is 2% by weight or less, and optionally the molar conversion of fatty alcohol to fatty aldehydes is more than 93%.

19.The method of any preceding claim wherein the amount of water absorbing or adsorbing material added is at least 10 g per mmol of fatty alcohol present in the reaction medium prior to oxidation, such as at least 15 g per mmol of fatty alcohol, such as at least 19 g per mmol of fatty alcohol, and wherein optionally the water absorbing or adsorbing material is a molecular sieve.

20.The method of any preceding claim, wherein the fatty aldehyde is selected from the group consisting of:

(Z)-Δ3 desaturated fatty aldehydes having a carbon chain length of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(E)-Δ3 desaturated fatty aldehydes having a carbon chain length of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(Z)-Δ5 desaturated fatty aldehydes having a carbon chain length of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(E)-Δ5 desaturated fatty aldehydes having a carbon chain length of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(Z)-Δ6 desaturated fatty aldehydes having a carbon chain length of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(E)-Δ6 desaturated fatty aldehydes having a carbon chain length of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(Z)-Δ7 desaturated fatty aldehydes having a carbon chain length of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(E)-Δ7 desaturated fatty aldehydes having a carbon chain length of 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(Z)-Δ8 desaturated fatty aldehydes having a carbon chain length of 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(E)-Δ8 desaturated fatty aldehydes having a carbon chain length of 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(Z)-Δ9 desaturated fatty aldehydes having a carbon chain length of 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(E)-Δ9 desaturated fatty aldehydes having a carbon chain length of 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(Z)-Δ10 desaturated fatty aldehydes having a carbon chain length of 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(E)-Δ10 desaturated fatty aldehydes having a carbon chain length of 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(Z)-Δ11 desaturated fatty aldehydes having a carbon chain length of 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(E)-Δ11 desaturated fatty aldehydes having a carbon chain length of 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(Z)-Δ12 desaturated fatty aldehydes having a carbon chain length of 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(E)-Δ12 desaturated fatty aldehydes having a carbon chain length of 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22;

(Z)-Δ13 desaturated fatty aldehydes having a carbon chain length of 14, 15, 16, 17, 18, 19, 20, 21 or 22; and

(E)-Δ13 desaturated fatty aldehydes having a carbon chain length of 14, 15, 16, 17, 18, 19, 20, 21 or 22; such as

(E)7,(Z)9 desaturated fatty aldehydes having a carbon chain length of 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, or 22,

(E)3,(Z)8,(Z)11 desaturated fatty aldehydes having a carbon chain length of 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, or 22,

(Z)9,(E)11,(E)13 desaturated fatty aldehydes having a carbon chain length of 14, 15, 16, 17, 18, 19, 20, 21, or 22,

(Z)11,(Z)13 desaturated fatty aldehydes having a carbon chain length of 14, 15, 16, 17, 18, 19, 20, 21 or 22,

(Z)9,(E)12 desaturated fatty aldehydes having a carbon chain length of 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22,

(E)7,(E)9 desaturated fatty aldehydes having a carbon chain length of 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22, and

(E)8,(E)10 desaturated fatty aldehydes having a carbon chain length of 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, or 22,

such as

(E)7,(Z)9 desaturated fatty aldehyde having a carbon chain length of 14,

(E)3,(Z)8,(Z)11 desaturated fatty aldehyde having a carbon chain length of 14,

(Z)9,(E)11,(E)13 desaturated fatty aldehyde having a carbon chain length of 14,

(E)7,(Z)9 desaturated fatty aldehyde having a carbon chain length of 12,

(E)3,(Z)8,(Z)11 desaturated fatty aldehyde having a carbon chain length of 12,

(Z)9,(E)11,(E)13 desaturated fatty aldehyde having a carbon chain length of 12,

(E)8,(E)10 desaturated fatty aldehyde having a carbon chain length of 12

(E)7,(E)9 desaturated fatty aldehyde having a carbon chain length of 11,

(Z)11,(Z)13 desaturated fatty aldehyde having a carbon chain length of 16, or

(Z)9,(E)12 desaturated fatty aldehyde having a carbon chain length of 14,

or such as

tetradecan-1-al, pentadecan-1-al, hexadecan-1-al, pentadecen-1-al, (Z)-9-hexadecen-1-al, (Z)-11-hexadecen-1-al, (7E,9E)-undeca-7,9-dien-1-al, (11Z, 13Z)-hexadecadien-1-al, (9Z,12E)-tetradecadien-1-al, and (8E,10E)-dodecadien-1-al.

21.The method of any preceding claim further comprising steps for purifying the fatty aldehyde comprising:

a) providing a purification mixture comprising:

i. the fatty aldehyde,

ii. copper ions, and

iii. a polar solvent;

b) mixing said purification mixture with an apolar, aprotic solvent and an acid to create an extraction mixture comprising an apolar phase and a polar phase allowing the fatty aldehyde to be extracted from the polar phase to the apolar phase and

c) separating the apolar phase comprising purified aldehyde from the polar phase.

22.The method of claim 21, wherein the purification mixture comprises 0.05 to 5.0 wt% copper ions, such as 0.05 to 2.0 wt% copper ions, such as 0.05 to 1.0 wt% copper ions.

23.The method of claims 21 to 22, wherein the acid is selected from the group consisting of C2-C8 monocarboxylic acids, C2-C8 dicarboxylic acids, and C6-C8 tricarboxylic acids, such as acetic acid or citric acid.

24.The fatty aldehyde purification method according to any one of claims 21 to 23, wherein at least 2.0 molar equivalent of acid relative to the copper ions is used, such as at least 2.4 equivalents.

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