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(54) **Title:** NOVEL PROCESS FOR THE MANUFACTURE OF METHYL LIMONITRILE

(57) **Abstract:** The present invention is directed to a process for the manufacture of methyl limonitrile comprising a mixture of 3,7-dimethyl-2,6-nonadiene nitrile, 3,7-dimethyl-3,6-nonadiene nitrile and 7-methyl-3-methylene-6-nonene nitrile comprising the following steps: a) reacting 6-methyl-5-octen-2-one with cyano acetic acid and removing carbon dioxide and water, wherein the reaction and the removal of carbon dioxide and water are performed in the presence of a base and a co-base in an organic solvent, wherein the base is pyridine, wherein the co-base is 1,4-diamino butane, and wherein the organic solvent is a solvent which forms a heteroazeotrop with water; b) removing the solvent and pyridine of the reaction mixture obtained after having performed step a) or step c) by distillation to obtain a reaction mixture; c) isomerizing the reaction mixture obtained after having performed step a) or step b) to obtain an isomerized reaction mixture; whereby step b) can be performed before or after step c).



5

Novel process for the manufacture of methyl limonitrile

Summary and background information

10 The present invention is directed to a process for the manufacture of methyl limonitrile. Methyl limonitrile is a mixture of 3,7-dimethyl-2,6-nonadiene nitrile (compound A), 7-methyl-3-methylene-6-nonene nitrile (compound B) and 3,7-dimethyl-3,6-nonadiene nitrile (compound C).

15 The process according to the invention comprises the step of reacting 6-methyl-5-octen-2-one (6-ethyl-5-hepten-2-one; EH) with cyano acetic acid and removing water and carbon dioxide, wherein the reaction and the removal of water and carbon dioxide are performed in the presence of a base and a co-base and in an organic solvent as shown in Fig. 1.

20

There is an increasing demand of substituting geranyl nitrile by another fragrance, which does not have the toxicological disadvantages of geranyl nitrile.

It is already known that methyl limonitrile, a mixture of 3,7-dimethyl-2,6-nonadiene nitrile (compound A), 7-methyl-3-methylene-6-nonene nitrile (compound B) and 3,7-dimethyl-3,6-nonadiene nitrile (compound C), wherein the amount of 7-methyl-3-methylene-6-nonene nitrile and 3,7-dimethyl-3,6-nonadiene nitrile in the mixture is in the range of from 10 to 30 weight-%, based on the total weight of the mixture, does have similar olfactive properties as geranyl nitrile.

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This especially applies to methyl limonitrile, wherein the ratio of compound A (3,7-dimethyl-2,6-nonadiene nitrile) in methyl limonitrile is in the range of 60 to 90 norm-% (preferably 70 to 85 norm-%, more preferably 76 to 83 norm-%, most preferably around 80 norm-%),

5 the ratio of compound B (7-methyl-3-methylene-6-nonene nitrile) is in the range of 0 to 10 norm-% (preferably 0 to 5 norm-%, more preferably 0 to 2 norm-%, most preferably around 0 norm-%), and
the ratio of compound C (3,7-dimethyl-3,6-nonadiene nitrile) in methyl limonitrile is in the range of from 10 to 30 norm-% (preferably 15 to 25 norm-%, more preferably 17 to
10 22 norm-%, most preferably around 20 norm-%), all based on the amount of compounds A, B and C together, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%,
and the total amount of methyl limonitrile in the mixture ,i.e. the purity, is 95-100 area-% (preferably 97-100 area-%, more preferably 98-100 area-%) as determined by gas
15 chromatography (GC), whereby the conditions for measurement are chosen in a way that all 10 stereoisomers (see Fig. 2) show distinct peaks in the gas chromatogram.

To further illustrate the meaning of “norm-%” an example is given:

In case there is a process product with a purity of methyl limonitrile of 95 area-% and
20 with an amount of compound A of 80 norm-% ($A : (A + B + C) = 80\%$), an amount of compound B of 0 norm-% and an amount of compound C of 20 norm-%, that in fact means that the amount of compound A in the process product is 76 area-% ($0.95 \times 80\%$), the amount of compound B in the process product is 0 area-% and the amount of compound C in the process product is 19 area-% ($0.95 \times 20\%$), based on the total weight
25 of the process product.

Such a product is already sold by Givaudan under the tradename “lemonile”. Lemonile is a mixture of 3,7-dimethyl-2,6-nonadiene nitrile, 7-methyl-3-methylene-6-nonene nitrile and 3,7-dimethyl-3,6-nonadiene nitrile, wherein the ratio 3,7-dimethyl-2,6-nonadiene
30 nitrile : 7-methyl-3-methylene-6-nonene nitrile : 3,7-dimethyl-3,6-nonadiene nitrile = 80 : 0 : 20 with a purity of > 98 area-%.

At present no process is known to manufacture such a product in an efficient and economic way at industrial scale.

5

Detailed description

Thus, this need is fulfilled by the present invention, which is directed to a process for the manufacture of a mixture comprising 3,7-dimethyl-2,6-nonadiene nitrile, 3,7-dimethyl-3,6-nonadiene nitrile and 7-methyl-3-methylene-6-nonene nitrile comprising the

10 following steps:

a) reacting 6-methyl-5-octen-2-one with cyano acetic acid and removing carbon dioxide and water, wherein the reaction and the removal of carbon dioxide and water are performed in the presence of a base and a co-base in an organic solvent, wherein the base is pyridine, wherein the co-base is 1,4-diamino butane, and

15 wherein the organic solvent is a solvent which forms a heteroazeotrop with water;

b) removing the solvent and pyridine of the reaction mixture obtained after having performed step a) or step c) by distillation to obtain a reaction mixture;

c) isomerizing the reaction mixture obtained after having performed step a) or step b) to obtain an isomerized reaction mixture;

20 whereby step b) can be performed before or after step c).

Starting materials:

Cyano acetic acid (CNA) and 6-methyl-5-octen-2-one (6-ethyl-5-hepten-2-one; EH) are used as starting materials. Usually the molar ratio of CNA to EH is in the range of (0.5 to 1.5 mol) : 1 mol, preferably in the range of (0.7 to 1.3 mol) : 1 mol, more preferably in the range of (0.75 to 1.1 mol) : 1 mol, most preferably in the range of (0.9 to 1.1 mol) : 1 mol.

Base

30 Pyridine is used as base.

Preferably the amount of the base is in the range of 0.5 to 1.5 mol per mol of EH, more preferably the amount of the base is in the range of 0.7 to 1.3 mol per mol of EH.

5 Co-base

1,4-diamino butane ("DAB") is used as co-base. It is an intermediate produced by DSM as well as by other suppliers.

Preferably the amount of the co-base is in the range of 0.005 to 0.15 mol per mol of EH,
10 more preferably the amount of the co-base is in the range of 0.01 to 0.1 mol per mol of EH, most preferably the amount of the co-base is in the range of 0.01 to 0.05 mol per mol of EH.

The co-base may be used as such, i.e. in substance, or also as aqueous solution. This is
15 especially advantageous for 1,4-diaminobutane which has a melting point of 27-28°C at atmospheric pressure, i.e. it is solid at room temperature, since an aqueous solution of DAB facilitates its dosing. The concentration of such aqueous solution is not critical.

Solvent

20 Forming a heteroazeotrop with water means that solvent and water form an azeotrop whereby solvent and water are not or only partially miscible with each other.

Preferred examples of such solvents are toluene, benzene, ortho-xylene, meta-xylene, para-xylene, hexane and heptane and any mixture thereof. More preferred only one
25 solvent of this group is used and not a mixture of two or more solvents. Most preferred toluene is used as solvent.

The amount of solvent is preferably in the range of 0.5 to 2 kg per kg of EH, more preferably the amount of solvent is in the range of 0.8 to 1.5 kg per kg of EH, even more
30 preferably the amount of solvent is in the range of 0.9 to 1.2 kg per kg of EH, most preferably the amount of solvent is in the range of 0.95 to 1.15 kg per kg of EH. These preferred amounts especially also apply if toluene is the solvent.

5 Reaction conditions

The manufacture of methyl limonitrile can be divided in several steps which are described in more detail below.

These steps are:

- 10 a) reaction of CNA and EH in presence of a base and a co-base;
- b) removal of the solvent and the base by distillation;
- c) isomerization of the reaction mixture (whereby the co-base is still present) obtained in step b) to the desired isomer ratio;
- d) extraction with diluted acids;
- 15 e) removal of high boiling impurities ("high boilers");
- f) removal of low boiling compounds ("low boilers), recycling of non-reacted 6-ethyl-5-hepten-2-one (EH).

Depending on which of these steps are performed different qualities of the product are
20 obtained which will be described in more detail in the chapter "product".

In the most preferred embodiment of the present invention all preferred conditions for each step a) to f) are realized; pyridine is used as base with the preferred amounts as given above, 1,4-diamino butane is used as co-base with the preferred amounts as given
25 above, toluene is used as solvent with the preferred amounts as given above, and CNA and EH are also used with the preferred amounts as given above.

All steps a) to f) are preferably carried out at inert conditions.

All steps a) to f) can also be carried out either batch-wise or continuously.

30 A further advantage of the present invention is that steps a) to c) can be carried out as a one-pot-process.

Step a) Reaction

- 5 The reaction is carried out at a pressure in the range of from 0.3 to 1.5 bar (absolute pressure), preferably at a pressure in the range of from 0.5 to 1.2 bar (absolute pressure), more preferably at a pressure in the range of from 0.7 to 1.0 bar (absolute pressure). The temperature at which the reaction of EH and CNA and the removal of H₂O and CO₂ is performed is defined by the temperature at which the reaction mixture is under reflux.

10

Step b) Removal of the solvent and the base by distillation

This step is carried out at a final temperature in the range of from 100 to 180°C, preferably at a final temperature in the range of from 120 to 160°C, more preferably at a final temperature in the range of from 130 to 150°C. In case toluene is the solvent and
15 pyridine is the base this step is carried out most preferably at a final temperature in the range of from 140 to 146°C. The distilled off solvent mixture (solvent and base; especially toluene and pyridine) can be used for further reaction batches within the methyl limonitrile production, i.e. it can be recycled back into step a).

- 20 The pressure at which this step is performed is preferably in the range of from 0.05 to 1 bar (absolute pressure), preferably in the range of from 0.1 to 1 bar (absolute pressure).

In case toluene is the solvent and pyridine is the base, the temperature increases up to 140 to 146°C during removal of the solvent mixture. Having reached this temperature the
25 pressure is decreased maintaining this temperature during further removal of the solvent mixture.

- It is recommended to almost completely remove the solvent and the base, as well as to recycle them back in step a), optionally after separating low boiling by-products before
30 recycling or purging a part of the solvent mixture.

Step c) Isomerization of the reaction mixture obtained in step b) to the desired isomer ratio

5 This step is carried out at a temperature in the range of from 100 to 180°C, preferably at a temperature in the range of from 120 to 160°C, more preferably at a temperature in the range of from 140 to 150°C. The pressure at which the isomerization is performed is not relevant and for practical reasons chosen within a range of from 0.1 to 2 bar (absolute pressure). Most convenient this step is performed at atmospheric pressure.

10

Since the solvent and the base have been removed in step b), it means that the co-base is still present. This co-base is the catalyst for the isomerization reaction beside being the catalyst for the formation of the 10 stereoisomers of methyl limonitrile as shown in Fig. 2.

15

In principle it is also possible to perform step c) before step b), i.e. that the reaction mixture obtained in step a) is first isomerized (at elevated pressure) and then the solvent and the base are removed, but this version is not recommended since the isomerization is then slower than when step c) is performed after step b), and the isomer ratio may further change during step b) if this step is performed after step c). Furthermore, in case the steps 20 are performed in the order a), c) and b), the amount of the co-base DAB in step a) should be increased, preferably to an amount in the range of 0.02 to 0.15 mol DAB per mol of EH to get the preferred desired isomer ratio.

25 The preferred desired isomer ratio in the context of the present invention is a ratio of 3,7-dimethyl-2,6-nonadiene nitrile (A) to 7-methyl-3-methylene-6-nonene nitrile (B) to 3,7-dimethyl-3,6-nonadiene nitrile (C) in the range of (76 to 83 norm-%) to (0 to 2 norm-%) to (17 to 22 norm-%), especially a ratio of 3,7-dimethyl-2,6-nonadiene nitrile (A) to 7-methyl-3-methylene-6-nonene nitrile (B) to 3,7-dimethyl-3,6-nonadiene nitrile (C) of 30 around 80 norm-% to around 0 norm-% to around 20 norm-%, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%.

Step d) Extraction with diluted acids

5 For the extraction of methyl limonitrile from the raw product obtained in step c), in case step c) is performed after step b) (preferred), or from the raw product obtained in step b), in case step b) is performed after step c), preferably an aqueous solution of a strong acid is used as extraction medium.

10 Examples of such extraction media are aqueous solutions of sulfuric acid, hydrochloric acid and acetic acid, whereby aqueous solutions of sulfuric acid are preferred. More preferred the extraction media have the following concentrations:

Diluted aqueous sulfuric acid: 1-10 weight-%, more preferred 4-8 weight-%;

diluted aqueous hydrochloric acid: 1-10 weight-%, more preferred 4-8 weight-%;

15 diluted aqueous acetic acid: 5-20 weight-%, more preferred 8-15 weight-%, whereby diluted aqueous sulfuric acid with the concentrations as given above is most preferred.

When the extraction medium is added to the raw product obtained in step c)/b) two phases are formed: an organic phase and an aqueous phase.

20

The treatment of the crude product obtained in step c)/b) with the extraction medium is preferably carried out at a temperature in the range of from 20 to 90°C, more preferably at a temperature in the range of from 40 to 70°C, most preferably at a temperature in the range of from 50 to 70°C.

25

The organic phase containing methyl limonitrile is separated from the aqueous phase and washed with deionised water. The washing with deionised water can be carried out several times. It has to be kept in mind that the organic phase contains small amounts of water. This water does not disturb the carrying out of the following step e), but has to be removed after step e) before step f) is performed.

30

The aqueous phases, i.e. the aqueous phase as obtained when the organic phase is separated off and the combined de-ionised wash waters, can also be back-extracted with the solvent, especially with toluene, whereby a further organic phase is obtained which

5 contains small amounts of water. The back-extraction increases the yield of methyl limonitrile but has the disadvantage in having to remove the solvent again before step e). The removal of the solvent, especially of toluene, may be achieved by rectification or distillation. During the removal of the solvent, especially of the toluene, small amounts of water are also removed.

10

Step e) Removal of high boiling impurities ("high boilers")

From the organic phase obtained in step d) the coloured components and other high boiling components are removed to gain a clear colorless to light yellow product (so-called "distillate"). This step is also beneficial for the isomer ratio stability. Suitable
15 conditions for this step: distillation at reduced pressure, preferably at a pressure in the range of 0 to 100 mbar (absolute pressure), more preferably at a pressure in the range of 10 to 50 mbar (absolute pressure), most preferably at a pressure in the range of 15 to 30 mbar (absolute pressure).

20 This step can be carried out in any suitable device known to the person skilled in the art such as e.g. in an evaporator (operated batch-wise or continuously), especially in a thin film evaporator or a fall film evaporator, or in a vessel.

Step f) Removal of low boiling compounds ("low boilers), Recycling of non-reacted 6-ethyl-5-hepten-2-one (EH)

25

In case the distillate produced by high boiler removal (product of step e)) is biphasic, which is the case when no back-extraction is carried out in step d) the aqueous phase should be separated before processing further.

30 The distillate produced by high boiler removal (product of step e)) or (if needed) the organic phase after aqueous phase removal is preferably processed further to a low boiler removal step: the low boiling compounds which contain mainly unconverted EH are separated by distillation or rectification under reduced pressure.

5 The hereby produced distillate is preferably completely (preferred) or partially taken back to the reaction (step a)) with cyano acetic acid in presence of a solvent (preferred toluene), a base (pyridine) and co-base (DAB) to partially substitute “fresh” EH. Even if all of the fresh EH is substituted by the distillate of the low-boiler removal step, the reaction runs well. Therefore the removal and recycling of unconverted recovered EH is
10 beneficial to increase the overall yield. To avoid accumulation of by-products it might be advantageous to purge a part of this recycle stream from time to time.

The bottom product is the final, well smelling product with a content of > 98 area-% of methyl limonitrile.

15

Product

Methyl limonitrile consists of 10 stereoisomers (compounds A, B and C), wherein 3,7-dimethyl-2,6-nonadiene nitrile (compound A) is in fact a mixture of four stereoisomers as shown in **Fig. 2**: 3,7-dimethyl-2*E*,6*E*-nonadiene nitrile, 3,7-dimethyl-2*E*,6*Z*-nonadiene
20 nitrile, 3,7-dimethyl-2*Z*,6*E*-nonadiene nitrile and 3,7-dimethyl-2*Z*,6*Z*-nonadiene nitrile.

The term “7-methyl-3-methylene-6-nonene nitrile” (compound B) encompasses two stereoisomers, i.e. 7-methyl-3-methylene-6*E*-nonene nitrile and 7-methyl-3-methylene-6*Z*-nonene nitrile (see **Fig. 2**).

25

3,7-dimethyl-3,6-nonadiene nitrile (compound C) is also a mixture of four stereoisomers (see **Fig. 2**): 3,7-dimethyl-3*E*,6*E*-nonadiene nitrile, 3,7-dimethyl-3*E*,6*Z*-nonadiene nitrile, 3,7-dimethyl-3*Z*,6*E*-nonadiene nitrile and 3,7-dimethyl-3*Z*,6*Z*-nonadiene nitrile.

30 The product obtained with the process of the present invention is methyl limonitrile, \diamond preferably wherein the ratio of 3,7-dimethyl-2,6-nonadiene nitrile is in the range of 60 to 90 norm-%, the ratio of 7-methyl-3-methylene-6-nonene nitrile is in the range of 0 to 10 norm-%, and the ratio of 3,7-dimethyl-3,6-nonadiene nitrile is in the range of from 10

- 5 to 30 norm-%, all based on the amount of compounds A, B and C together, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%;
- ◇ more preferably wherein the ratio of 3,7-dimethyl-2,6-nonadiene nitrile is in the range of 70 to 85 norm-%, the ratio of 7-methyl-3-methylene-6-nonene nitrile is in the range of 0 to 5 norm-%, and the ratio of 3,7-dimethyl-3,6-nonadiene nitrile is in the range of from
- 10 15 to 25 norm-%, all based on the amount of compounds A, B and C together, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%;
- ◇ even more preferably wherein the ratio of 3,7-dimethyl-2,6-nonadiene nitrile is in the range of 76 to 83 norm-%, the ratio of 7-methyl-3-methylene-6-nonene nitrile is in the range of 0 to 2 norm-%, and the ratio of 3,7-dimethyl-3,6-nonadiene nitrile is in the range
- 15 of from 17 to 22 norm-%, all based on the amount of compounds A, B and C together, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%;
- ◇ most preferably wherein the ratio of 3,7-dimethyl-2,6-nonadiene nitrile is around 80 norm-%, the ratio of 7-methyl-3-methylene-6-nonene nitrile is around 0 norm-%, and the ratio of 3,7-dimethyl-3,6-nonadiene nitrile is around 20 norm-%, all based on the amount
- 20 of compounds A, B and C together, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%.

Depending on which of these steps are performed different qualities of the product are obtained:

- 25 ◇ If only steps a) to c) or steps a), c) and b) are performed methyl limonitrile of crude quality is obtained. "Crude quality" in the context of the present invention means methyl limonitrile before further purification, but with the desired ratio of the stereoisomers A, B and C as given above in norm-%.
- 30 ◇ If all steps a) to f) are carried out (see description of the most preferred embodiment of the invention below and Fig. 7) methyl limonitrile of olfactive quality is obtained.
- "Olfactive quality" in the context of the present invention means a pure, colourless, good-smelling product which is suitable for use as flavor and fragrance and has a purity > 98 area-%.

5

Fields of use of methyl limonitrile of olfactive quality are aromatization of consumer articles or everyday commodities. Non-limiting examples of such consumer articles and everyday commodities are cleaning compositions, e.g. scouring compositions, cleaners; care compositions for the treatment of surfaces, e.g. of furniture, floors, kitchen appliances, glass panes and windows, and also windcreens; detergents, softeners; laundry treatment compositions; textile treatment compositions, e.g. ironing aids; and also bleaches and bleach liquors, toilet blocks, limescale removers, air fresheners (air care); fragrance compositions, e.g. for fine perfumery; cosmetic compositions, but also fertilizers, building materials, mold removers, disinfectants, and products for car care.

15

◇ If step e) (high boiler removal) is not performed the methyl limonitrile is not colourless.

◇ If step f) (low boiler removal) is not performed the methyl limonitrile is stinking.

20

Description of the drawings

Fig. 1 shows the reaction scheme of the manufacture of methyl limonitrile (step a).

Fig. 2 shows the 10 methyl limonitrile stereoisomers (compounds A, B, C).

25

Fig. 3 shows the concentration - time diagram for the following reaction conditions: 0.75 mol of CNA, 1.2 mol of pyridine, 0.04 mol of 1,4-diaminobutane and 1 mol of EH, 1.1 kg of toluene per 1 kg of EH, whereby the reaction mixture was held for 4 hours under reflux.

30

“A” means “compound A”, “B” means “compound B” and “C” means “compound C”. The X-axis gives the reaction time in hours [h], the Y1-axis (left side) gives the content of compounds A, B and C in [area-%] and the Y2-axis (right side) gives the content of EH in [area-%].

5 **Fig. 4** shows the concentration - time diagram for the following reaction conditions:
0.75 mol of CNA, 1.2 mol of pyridine, 0.04 mol of ammonium acetate and 1 mol of EH,
1.1 kg of toluene per 1 kg of EH, whereby the reaction mixture was held for 6 hours
under reflux.

“A” means “compound A”, “B” means “compound B” and “C” means “compound C”.

10 The X-axis gives the reaction time in hours [h], the Y1-axis (left side) gives the content
of compounds A, B and C in [area-%] and the Y2-axis (right side) gives the content of
EH in [area-%].

15 **Fig. 5** shows the stability of methyl limonitrile isomers after extraction and high boiler
removal at a temperature of 140°C, whereby the X-axis gives the time in hours [h], the
Y1-axis (left side) gives the ratio of compounds B and C in [norm-%] and the Y2-axis
(right side) gives the ratio of compound A in [norm-%].

20 **Fig. 6** shows the concentration-time diagram for the whole sequence: reaction (step a)),
distillation (step b)), isomerization (step c)) under the following conditions:
Mixture of 1 mol of cyano acetic acid, 1.2 mol of pyridine, 0.01 mol of 1,4-diamino
butane and 1 mol of EH as well as 1.1 kg of toluene per 1 kg of EH held under reflux for
2 hours, solvent + base removal (removal of toluene and pyridine) within 4 hours, 4 hours
isomerization at 141°C.

25 “A” means “compound A”, “B” means “compound B”, “C” means “compound C”, “Start
dist.” means “start of distillation”, i.e. starting the removal of pyridine and toluene (step
b)), “end dist.” means “end of distillation”, i.e. end of step b). The X-axis gives the
(reaction) time in hours [h], the Y1-axis (left side) gives the content of compounds A, B
and C in [area-%] and the Y2-axis (right side) gives the content of EH in [area-%].

30

Fig.7 visualizes the process of the present invention with all steps a) to f).

Most preferred embodiment of the present invention

5 The most preferred embodiment of the present invention is a process for the manufacture of methyl limonitrile of olfactive quality comprising a mixture of 3,7-dimethyl-2,6-nonadiene nitrile, 3,7-dimethyl-3,6-nonadiene nitrile and 7-methyl-3-methylene-6-nonene nitrile comprising the following steps:

- 10 a) reacting 6-methyl-5-octen-2-one with cyano acetic acid and removing carbon dioxide and water, wherein the reaction and the removal of carbon dioxide and water are performed in the presence of pyridine as base and 1,4-diamino butane as co-base in toluene as organic solvent;
- b) removing toluene and pyridine by distillation to obtain a reaction mixture;
- 15 c) isomerizing the reaction mixture obtained after having performed step b) to obtain an isomerized reaction mixture;
- d) extracting the isomerized reaction mixture with diluted acids whereby an organic phase and an aqueous phase are formed, separating the organic phase containing the methyl limonitrile from the aqueous phase, and washing the organic phase one or more times with deionized water;
- 20 d-2) optionally back-extracting the aqueous phase obtained in step d) with toluene and afterwards removing the toluene, whereby the thus removed toluene is optionally recycled into step d-2);
- e) separating off coloured components and high boiling impurities from the organic phase obtained in step d);
- 25 f) separating off low boiling impurities from the distillate obtained in step e) to achieve the olfactive quality, whereby these low boiling impurities are mainly EH;
- f2) optionally recycling the EH obtained in step f) back into step a).

30 Steps a), b), c), d), e) and f) are performed as described above, also with the preferred conditions as given.

Step d2)

5 The back-extraction with toluene increases the overall yield of methyl limonitrile but has the disadvantage in having to remove the toluene again before step e). The removal of the toluene may be achieved by rectification or distillation and can be carried out batch-wise or continuously.

10 Thus, preferably the back-extraction is not carried out. If it is, however, carried out, the thus removed toluene is advantageously recycled back into step d-2) and used again for further back-extraction.

In case the distillate produced by high boiler removal (product of step e)) is biphasic, the
15 water phase should be separated before processing further. This is the case when no back-extraction is carried out.

Step f2)

Preferably this step is performed, i.e. the thus removed unconverted EH is completely
20 (preferred) or partially recycled back into step a).

The term "methyl limonitrile mixture of olfactive quality" means that the purity of this mixture is > 98 area-%.

25 The invention is now further illustrated in the following non-limiting examples.

Examples

Example 1

30 I) Preparation of methyl limonitrile

In a 0.5 litre reactor (double jacketed) with condenser, dean stark apparatus and stirrer 153 g (ca. 180 ml) of toluene, 85.5 g (1 mol) of cyano acetic acid, 140 g (1 mol) of ethylheptenone (EH), 99 g of pyridine, and 0.95 g (0.01 mol) of 1,4-diaminobutane are filled into the reactor under N₂ and heated up. The mixture is held under reflux for 2

5 hours including water and carbon dioxide removal. Subsequently the solvent (mainly consisting of toluene and pyridine) is slowly distilled off within 4 hours. Thereby the inner temperature increases to 141°C and for nearly complete removal of the solvents vacuum is applied (down to 200 mbar absolute pressure) by maintaining an inner temperature of 141°C. Afterwards the reaction mixture is isomerized within four
10 additional hours at 141°C to achieve the desired isomer ratio. The reaction mixture is weighed (148.8 g) and analysed by GC: 11 weight-% EH, 78.8 weight-% methyl limonitrile (isomer ratio A : B : C = 80.2 : 0.1 : 19.6 – all in norm-%).

Result: EH conversion: 85.6%; yield methyl limonitrile based on EH: 75.3%; selectivity
15 methyl limonitrile based on EH: 87.9%.

II) Extraction of the reaction mixture

145.1 g of the reaction mixture obtained in I are washed with 52.1 g of diluted sulfuric acid (8 weight-% H₂SO₄ in water) for 30 minutes at 60°C. After phase separation the
20 organic layer is additionally washed with 49.3 g of deionised water at 60°C. The combined water layers are back washed with 41.8 g of toluene at 60°C. This back extraction of the aqueous layers with toluene can be skipped with only minor losses of yield. Skipping of the toluene back washing results in skipping of the toluene distillation step as well.

25

Result: Extraction yield methyl limonitrile: 99.7%.

III) Toluene and high boiler removal

49.8 g of the combined organic layers (extraction, back extraction) are distilled in a rotary
30 evaporator at a bath temperature of 100°C and 30 mbar for ½ hour to remove the toluene (5.23 g). Afterwards the bath temperature is increased to 180°C. 34.83 g of distillate with the following composition are obtained: 4 weight-% of toluene, 14 weight-% of EH, 79 weight-% of methyl limonitrile (A : B : C = 72.3 : 0.2 : 27.5). The high boiling impurities remain as residue.

5

Result: yield methyl limonitrile in distillate: 92% (i.e. 92% of the methyl limonitrile used for the distillation). In another example a yield of 96.5% was achieved.

IV) Recycling of non-reacted 6-ethyl-5-hepten-2-one (EH)

- 10 The distillate produced by high boiler removal (see III) is processed further to a low boiler removal step: the low boiling compounds, mainly EH and toluene, are separated by distillation or rectification under reduced pressure. The hereby produced distillate is taken back to the reaction with cyano acetic acid in presence of toluene, pyridine and 1,4-diaminobutane (DAB) to partially substitute “fresh” EH. Even if all of the fresh EH is
- 15 substituted by the distillate of the low-boiler removal step, the reaction runs well. Therefore the removal and recycling of unconverted EH is beneficial to increase the overall yield.

Examples 2 to 7: Variation of the base

- 20 The results of the examples 2 to 7 are summarized in the enclosed **table 1**. The conversion is based on the amount of 6-ethyl-5-hepten-2-one (EH). The yield is the molar amount of methyl limonitrile based on the molar amount of 6-ethyl-5-hepten-2-one.
- The selectivity is the molar amount of methyl limonitrile, based on the molar amount of
- 25 converted 6-ethyl-5-hepten-2-one.
- The examples are performed as described under Example 1 – I) and II), i.e. without performing steps III) and IV). If the conditions differ from the ones of example 1 the differences are given here or in **table 1**.
- Reaction time (step a): 6 hours (at reflux) if not indicated otherwise; 0.25 hours
- 30 distillation (step b)), 0 hour isomerization (step c)).
- Molar ratio cyano acetic acid : 6-ethyl-5-hepten-2-one = 0.75 mol / mol.

- 5 It is not possible to get the desired ratio of the stereoisomers of methyl limonitrile with ammonium acetate as co-base, see examples 5 and 6 in **table 1**, as the compounds C do not isomerize further to the compounds A.

Examples 8 to 19: Variation of the co-base

- 10 The results of the examples 8 to 19 are summarized in the enclosed **table 2**.
The conversion is based on the amount of 6-ethyl-5-hepten-2-one.
The yield is the molar amount of methyl limonitrile, based on the molar amount of 6-ethyl-5-hepten-2-one.
The selectivity is the molar amount of methyl limonitrile, based on the molar amount of
15 converted 6-ethyl-5-hepten-2-one.
The examples are performed as described under Example 1 – I) and II), i.e. without performing steps III) and IV). If the conditions differ from the ones of example 1 the differences are given here or in **table 2**.
Reaction time (step a)): 4 hours (at reflux) if not indicated otherwise, 0.25 hours
20 distillation (step b)), 0 hour isomerization (step c)).
Molar ratio cyano acetic acid : 6-ethyl-5-hepten-2-one : = 0.75 mol/mol.

Examples 20 to 39: Pyridine – 1,4-diaminobutane

- 25 a) Examples 20 to 22: Variation of the amount of cobase 1,4-diaminobutane
The results are summarized in **table 3** below. The examples are performed as described under Example 1 – I) and II), i.e. without performing steps III) and IV). If the conditions differ from the ones of example 1 the differences are given here or in **table 3**.
30 Amount of cyano acetic acid = 0.75 mol; amount of 6-ethyl-5-hepten-2-one (EH) = 1 mol; amount of pyridine = 1.25 mol.

Reaction time (step a)): 4 hours (at reflux) if not indicated otherwise; 0.25 hours
distillation (step b)), 0 hour isomerization (step c)).

5

Table 3

Example	Molar ratio 1,4-diaminobutane : EH	Ratio A : B : C [norm-%]	Conversion [%]	Yield [%]	Selectivity [%]
20	0.012	55 : 3 : 42	64.9	56.3	87
21	0.022	62 : 0 : 38	65	61.5	94.6
16	0.043	70 : 0 : 30	63.8	58.4	91.6
22	0.088	74 : 0 : 26	65.7	51.4	78.2

b) Examples 23 to 26: Variation of the amount of the base pyridine

10 The results are summarized in **table 4** below. The examples are performed as described under Example 1 – I) and II), i.e. without performing steps III) and IV). If the conditions differ from the ones of example 1 the differences are given here or in **table 4**.

Amount of cyano acetic acid = 0.75 mol; amount of 6-ethyl-5-hepten-2-one (EH) = 1 mol; amount of 1,4-diaminobutane = 0.04 mol.

15

Reaction time (step a)): 4 hours (at reflux) if not indicated otherwise; 0.25 hours distillation (step b)), 0 hour isomerization (step c)).

Table 4

Example	Molar ratio pyridine : EH	Ratio A : B : C [norm-%]	Conversion [%]	Yield [%]	Selectivity [%]
23	1.264	66 : 0 : 34	68.9	52.6	76.3
24	1.065	68 : 0 : 32	70.5	55.0	78.0
25	0.798	70 : 0 : 30	68.9	63.1	91.6

26	0.541	69 : 0 : 31	74.4	55.9	75.1
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5

c) Examples 27 to 29: Variation of the amount of cyano acetic acid

The results are summarized in **table 5** below. The examples are performed as described under Example 1 – I) and II), i.e. without performing steps III) and IV). If the conditions differ from the ones of example 1 the differences are given here or in **table 5**.

10

Amount of cyano acetic acid: x mol, amount of pyridine = $1.65 \cdot x$ mol; amount of 6-ethyl-5-hepten-2-one (EH) = 1 mol; amount of 1,4-diaminobutane = 0.04 mol.

Reaction time (step a)): 4 hours (at reflux) if not indicated otherwise; 0.25 hours

15

distillation (step b)), 0 hour isomerization (step c)).

Table 5

Example	Molar ratio cyano acetic acid : EH	Ratio A : B : C [norm-%]	Conversion [%]	Yield [%]	Selectivity [%]
16	0.795	70 : 0 : 30	63.8	58.4	91.6
27	0.902	65 : 0 : 35	69.6	65	93.3
28	0.998	60 : 0 : 40	75.9	68.4	90
29	1.066 ($1.25 \cdot x$ mol of pyridine)	41 : 0 : 39	81.5	67.4	82.7

d) Examples 30 to 32: Variation of the dosage time of 6-ethyl-5-hepten-2-one (EH)

20

The results are summarized in **table 6** below. The examples are performed as described under Example 1 – I) and II), i.e. without performing steps III) and IV). If the conditions differ from the ones of example 1 the differences are given here or in **table 6**.

- 5 Amount of cyano acetic acid = 0.75 mol; amount of 6-ethyl-5-hepten-2-one (EH) = 1 mol; amount of pyridine = 1.3 mol; amount of 1,4-diaminobutane (DAB) = 0.04 mol.

Reaction time (step a): 4 hours (at reflux) if not indicated otherwise, 0.25 hours distillation (step b)), 0 hour isomerization (step c)).

10

Table 6

Example	Dosage time in hours	Ratio A : B : C [norm-%]	Conversion [%]	Yield [%]	Selectivity [%]
30	0	63 : 0 : 37	62.6	51.4	82.2
31	2	61 : 0 : 39	62.7	48.0	76.6
32	3	62 : 0 : 38	59.8	45.8	76.5

e) Examples 33 to 39: Influence of the temperature, the amount and the concentration of the co-base on the isomerization

- 15 The results are summarized in the enclosed **table 7**. The examples are performed as described under Example 1 – I. If the conditions differ from the ones of example 1 the differences are given here or in **table 7**.

Amount of cyano acetic acid = 1 mol; amount of 6-ethyl-5-hepten-2-one (EH) = 1 mol;
 20 amount of pyridine = 1.2 mol;
 2 hours at reflux, 2 hours for (partial) solvent removal, 4 hours for isomerization.

f) Examples 40 to 42: Recycling of unconverted EH

- The results are summarized in **table 8** below. The examples are performed as described
 25 under Example 1 – I. If the conditions differ from the ones of example 1 the differences are given here or in **table 8**.

- 5 Amount of cyano acetic acid = 1 mol; amount of 6-ethyl-5-hepten-2-one = 1 mol; amount of pyridine = 1.3 mol, amount of 1,4-diamino butane = 0.01 mol.
2 hours at reflux (700 mbara), 4 hours for solvent removal, 2 hours for isomerization at 141°C.

10 **Table 8**

Example	Purity of 6-ethyl-5-hepten-2-one [weight-%]	Ratio A : B : C [norm-%]	Conversion [%]	Yield [%]	Selectivity [%]
40	96.7 8 (fresh)	78 : 0 : 22	90.4	78.7	87.0
41	90.1 (distillate)	80 : 0 : 20	88.6	76.6	86.4
42	77.2 (distillate)	83 : 0 : 17	90.4	79.4	87.9

As can be seen from **table 8** unconverted EH can successfully be used for further reaction batches.

5 Table 1 – Variation of the base

Example	Base	Amount of base [mol/mol EH]	Co-base	Amount of co-base [mol/mol EH]	Ratio A : B : C [norm-%]	Conversion [%]	Yield [%]	Selectivity [%]
2	pyridine	1.14	none	0	7 : 34 : 59	33.6	19	56.5
3	pyridine	1.14	ammonium acetate (NH ₄ OAc)	0.04	12 : 34 : 54	66.8	63	94.4
4	pyridine	1.23	NH ₄ OAc	0.04	12 : 36 : 52	67.3	61.4	91.2
5	Pyridine (24 hours)	1.23	NH ₄ OAc	0.04	22 : 24 : 54	68.2	63.4	93.0
6	Pyridine (48 hours)	1.24	NH ₄ OAc	0.04	39 : 9 : 52	66.4	63.1	94.9
7	piperidine	1.22	NH ₄ OAc	0.04	99 : 0 : 1	39	34.6	88.7

5 Table 2 – Variation of the co-base

Example	Base	Amount of base [mol]	Co-base	Amount of co-base [mol]	Ratio A : B : C [norm-%]	Conversion [%]	Yield [%]	Selectivity [%]
8	pyridine	1.31	aqueous ammonia solution (25 weight-%)	0.05	8 : 38 : 54	63.7	65.8	103
9	pyridine	1.32	aqueous ammonia solution (25 weight-%) and after 2 hours 1,4-diaminobutane	0.15 0.01	49 : 7 : 44	72.0	57.1	79.33
10	pyridine (6 hours)	1.14	piperidine	0.04	58 : 0 : 42	38.1	31.6	83.1
11	pyridine	1.14	morpholine	0.04	11 : 39 : 50	46.7	43.7	93.8
12	pyridine	1.32	ethylene diamine	0.05	59 : 1 : 40	72.2	61.7	85.6
13	pyridine	1.24	diethylene triamine	0.04	67 : 0 : 33	67.5	57.0	84.4
14	pyridine	1.27	1,4-diaminobutane	0.01	55 : 3 : 42	64.7	56.3	87.0
15	pyridine	1.27	1,4-diaminobutane	0.04	68 : 0 : 32	70.6	51.8	73.3
16	pyridine	1.31	1,4-diaminobutane	0.04	70 : 0 : 30	63.8	58.4	91.6
17	pyridine (6 hours)	1.31	1,4-diaminobutane	0.04	70 : 0 : 30	68.7	52.8	76.9
18	pyridine	1.32	1,4-diaminobutane	0.04	68 : 0 : 32	68.5	54.3	79.3
19	pyridine	1.32	NH ₄ OAc and after 2 hours 1,4-diaminobutane	0.04 0.01	37 : 16 : 47	69.7	58.1	83.4

5 Table 7

Example	Amount of co-base DAB [mol/mol EH]	Residual solvent (toluene/pyridine) [weight-%]	Isomerization Temperature [°C]	Ratio A : B : C [norm-%]	Conversion [%]	Yield [%]	Selectivity [%]
33	0.01	<5	143	75 : 0 : 25	86.7	77.2	89.0
34	0.01	<5	168	91 : 0 : 9	87.1	70.6	81.1
35	0.02	<5	143	91 : 0 : 9	91.2	71.8	78.7
36	0.01	40	132	61 : 0 : 39	84.3	75.3	89.3
37	0.01	29	143	60 : 0 : 40	82.8	75.1	90.7
38	0.01	20	153	76 : 0 : 24	85.8	73.5	85.7
39	0.01	<5	168	91 : 0 : 9	87.1	70.6	81.1

5

Claims

1. A process for the manufacture of methyl limonitrile comprising a mixture of 3,7-dimethyl-2,6-nonadiene nitrile, 3,7-dimethyl-3,6-nonadiene nitrile and 7-methyl-3-methylene-6-nonene nitrile comprising the following steps:
 - 10 a) reacting 6-methyl-5-octen-2-one with cyano acetic acid and removing carbon dioxide and water, wherein the reaction and the removal of carbon dioxide and water are performed in the presence of a base and a co-base in an organic solvent, wherein the base is pyridine, wherein the co-base is 1,4-diamino butane, and wherein the organic solvent is a solvent which forms a heteroazeotrop with water;
 - 15 b) removing the solvent and pyridine of the reaction mixture obtained after having performed step a) or step c) by distillation to obtain a reaction mixture;
 - c) isomerizing the reaction mixture obtained after having performed step a) or step b) to obtain an isomerized reaction mixture;whereby step b) can be performed before or after step c).
- 20 2. The process according to claim 1, wherein the organic solvent is selected from the group consisting of toluene, benzene, ortho-xylene, meta-xylene, para-xylene, hexane, heptane, and any mixture thereof.
- 25 3. The process according to claim 1 and/or 2, wherein the organic solvent is toluene.
4. The process according to any one or more of the preceding claims, wherein the steps are performed in the order a), b) and c), i.e. step b) is performed before step c).
- 30 5. The process according to any one or more of the preceding claims, wherein the removed solvent and pyridine are recycled back into step a).
6. The process according to any one or more of the preceding claims, comprising the additional step (step d)) of extracting the isomerized reaction mixture with diluted

- 5 acids whereby an organic phase and an aqueous phase are formed, separating the organic phase containing the methyl limonitrile from the aqueous phase, and washing the organic phase one or more times with deionized water.
7. The process according to claim 6, comprising the additional step of back-extracting
10 the aqueous phase with the solvent and removing the solvent.
8. The process according to claim 6 and/or 7, comprising the additional step (step e)) of separating off coloured components and high boiling impurities from the organic phase.
- 15 9. The process according to claim 8, comprising the additional step (step f) of separating off the low boiling impurities.
10. The process according to claim 9, wherein the low boiling impurities contain
20 unconverted 6-methyl-5-octen-2-one, comprising the additional step of recycling this low boiling 6-methyl-5-octen-2-one completely or partially back to the reaction (step a)).
11. A process for the manufacture of methyl limonitrile of olfactive quality comprising
25 a mixture of 3,7-dimethyl-2,6-nonadiene nitrile, 3,7-dimethyl-3,6-nonadiene nitrile and 7-methyl-3-methylene-6-nonene nitrile comprising the following steps:
- 30 a) reacting 6-methyl-5-octen-2-one with cyano acetic acid and removing carbon dioxide and water, wherein the reaction and the removal of carbon dioxide and water are performed in the presence of pyridine as base and 1,4-diamino butane as co-base in toluene as organic solvent;
- b) removing toluene and pyridine by distillation to obtain a reaction mixture;
- c) isomerizing the reaction mixture obtained after having performed step b) to obtain an isomerized reaction mixture;

- 5 d) extracting the isomerized reaction mixture with diluted acids whereby an organic phase and an aqueous phase are formed, separating the organic phase containing the methyl limonitrile from the aqueous phase, and washing the organic phase one or more times with deionized water;
- 10 d-2) optionally back-extracting the aqueous phase obtained in step d) with toluene and afterwards removing the toluene, whereby the thus removed toluene is optionally recycled into step d-2);
- e) separating off coloured components and high boiling impurities from the organic phase obtained in step d);
- 15 f) separating off low boiling impurities from the distillate obtained in step e), whereby these low boiling impurities contain unconverted 6-methyl-5-octen-2-one;
- f2) optionally recycling the 6-methyl-5-octen-2-one back into step a).
12. The process according to any one or more of the preceding claims, wherein the
- 20 molar ratio of cyano acetic acid to 6-methyl-5-octen-2-one is in the range of (0.5 to 1.5 mol) : 1 mol, preferably in the range of (0.7 to 1.3 mol) : 1 mol, more preferably in the range of (0.75 to 1.1 mol) : 1 mol, most preferably in the range of (0.9 to 1.1 mol) : 1 mol.
- 25 13. The process according to any one or more of the preceding claims, wherein the amount of pyridine is in the range of 0.5 to 1.5 mol per mol of 6-methyl-5-octen-2-one, preferably the amount of pyridine is in the range of 0.7 to 1.3 mol per mol of 6-methyl-5-octen-2-one.
- 30 14. The process according to any one or more of the preceding claims, wherein the amount of 1,4-diaminobutane is in the range of 0.005 to 0.15 mol per mol of 6-methyl-5-octen-2-one, preferably the amount of 1,4-diaminobutane is in the range of 0.01 to 0.1 mol per mol of 6-methyl-5-octen-2-one, more preferably the amount

5 of 1,4-diaminobutane is in the range of 0.01 to 0.05 mol per mol of 6-methyl-5-octen-2-one.

15. The process according to any one or more of the preceding claims, wherein the amount of solvent is in the range of 0.5 to 2 kg per kg of 6-methyl-5-octen-2-one, preferably the amount of solvent is in the range of 0.8 to 1.5 kg per kg of 6-methyl-5-octen-2-one, more preferably the amount of solvent is in the range of 0.9 to 1.2 kg per kg of 6-methyl-5-octen-2-one, most preferably the amount of solvent is in the range of 0.95 to 1.15 kg per kg of 6-methyl-5-octen-2-one.

15 16. The process according to any one or more of the preceding claims, wherein the ratio of 3,7-dimethyl-2,6-nonadiene nitrile is in the range of 60 to 90 norm-%, the ratio of 7-methyl-3-methylene-6-nonene nitrile is in the range of 0 to 10 norm-%, and the ratio of 3,7-dimethyl-3,6-nonadiene nitrile is in the range of from 10 to 30 norm-%, all based on the amount of compounds A, B and C together, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%.

17. The process according to any one or more of the preceding claims, wherein the ratio of 3,7-dimethyl-2,6-nonadiene nitrile is in the range of 70 to 85 norm-%, the ratio of 7-methyl-3-methylene-6-nonene nitrile is in the range of 0 to 5 norm-%, and the ratio of 3,7-dimethyl-3,6-nonadiene nitrile is in the range of from 15 to 25 norm-%, all based on the amount of compounds A, B and C together, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%.

18. The process according to any one or more of the preceding claims, wherein the ratio of 3,7-dimethyl-2,6-nonadiene nitrile is in the range of 76 to 83 norm-%, the ratio of 7-methyl-3-methylene-6-nonene nitrile is in the range of 0 to 2 norm-%, and the ratio of 3,7-dimethyl-3,6-nonadiene nitrile is in the range of from 17 to 22 norm-%, all based on the amount of compounds A, B and C together, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%.

5

19. The process according to any one or more of the preceding claims, wherein the ratio of 3,7-dimethyl-2,6-nonadiene nitrile is around 80 norm-%, the ratio of 7-methyl-3-methylene-6-nonene nitrile is around 0 norm-%, and the ratio of 3,7-dimethyl-3,6-nonadiene nitrile is around 20 norm-%, all based on the amount of compounds A, B and C together, where the ratios of A, B and C given in norm-% sum up to a total of 100 norm-%.

10

Fig. 1

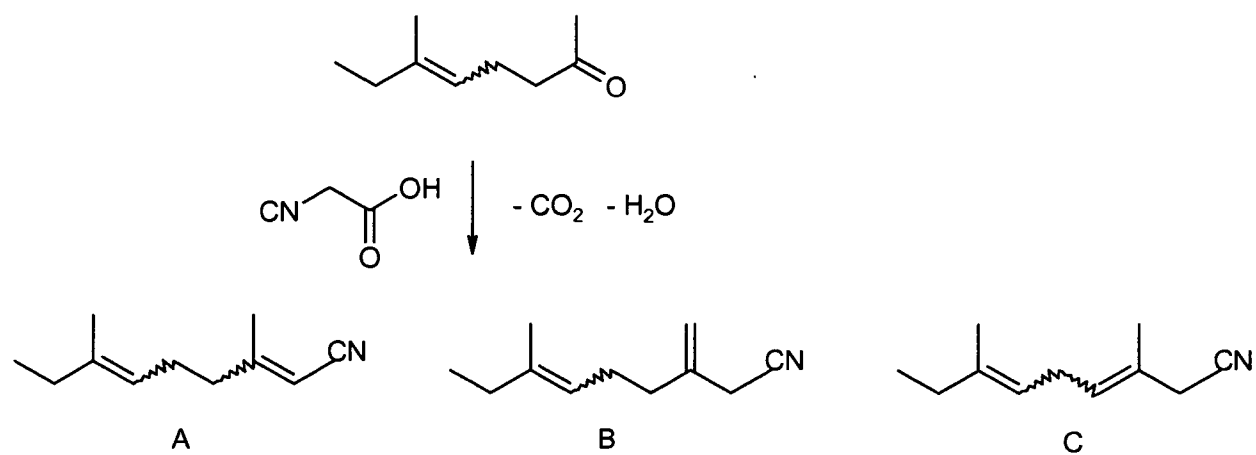


Fig. 2

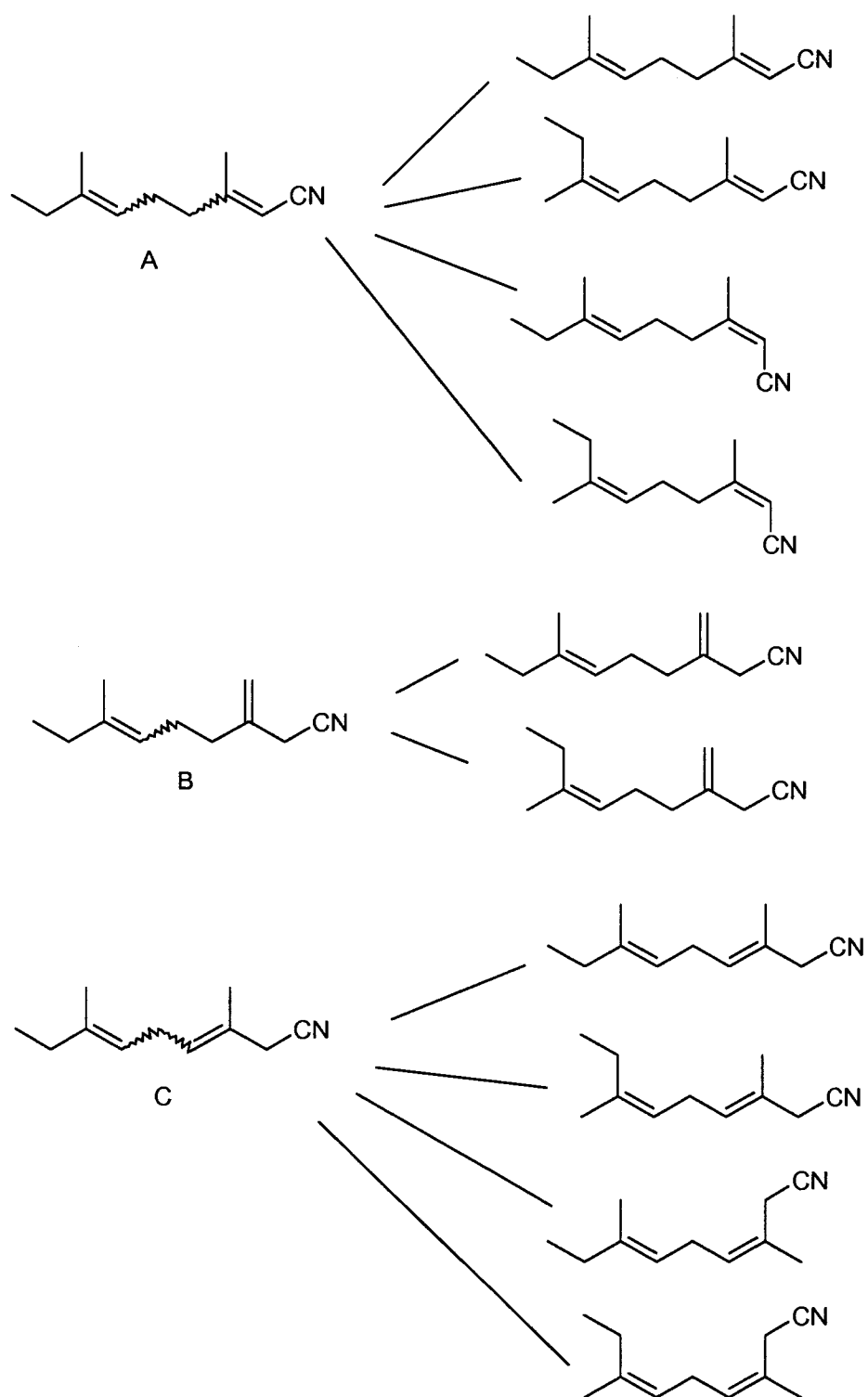


Fig. 3

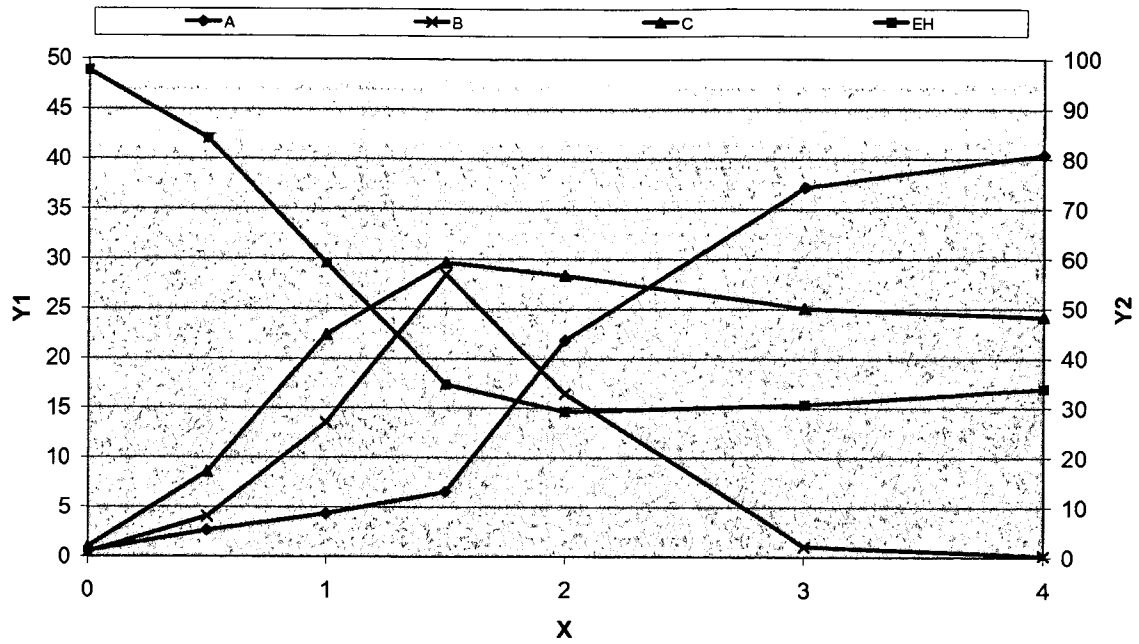


Fig. 4

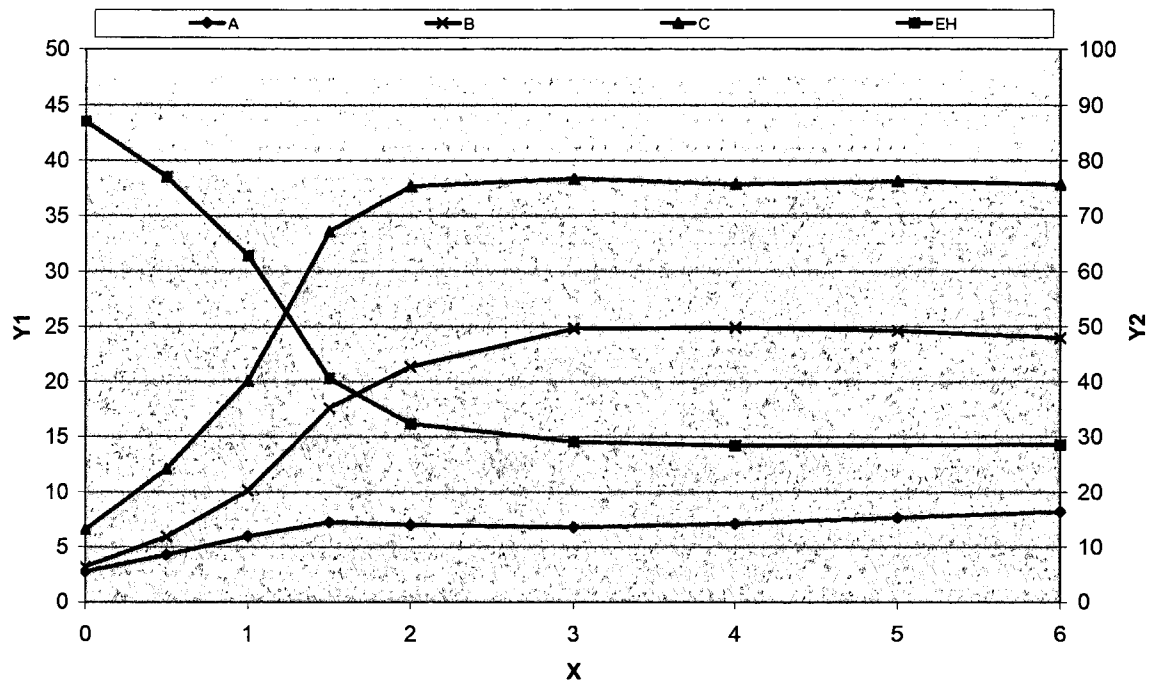


Fig. 5

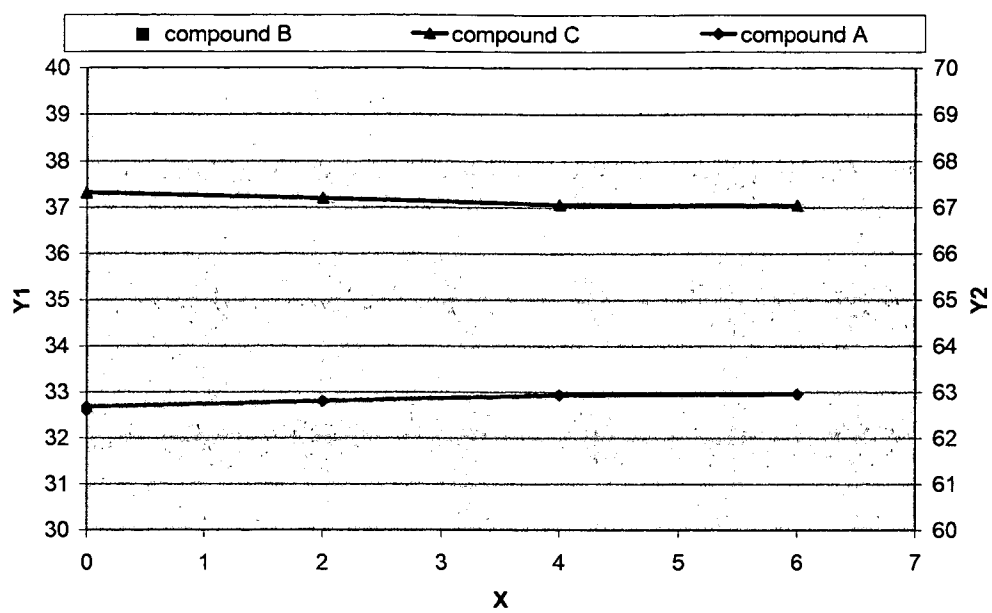


Fig. 6

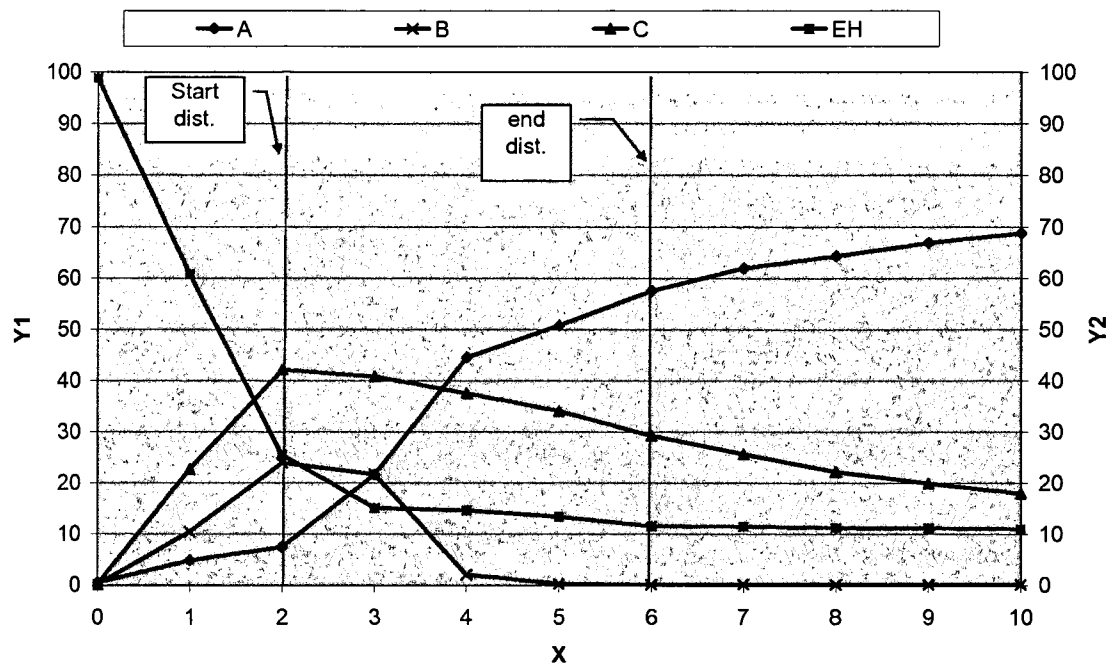
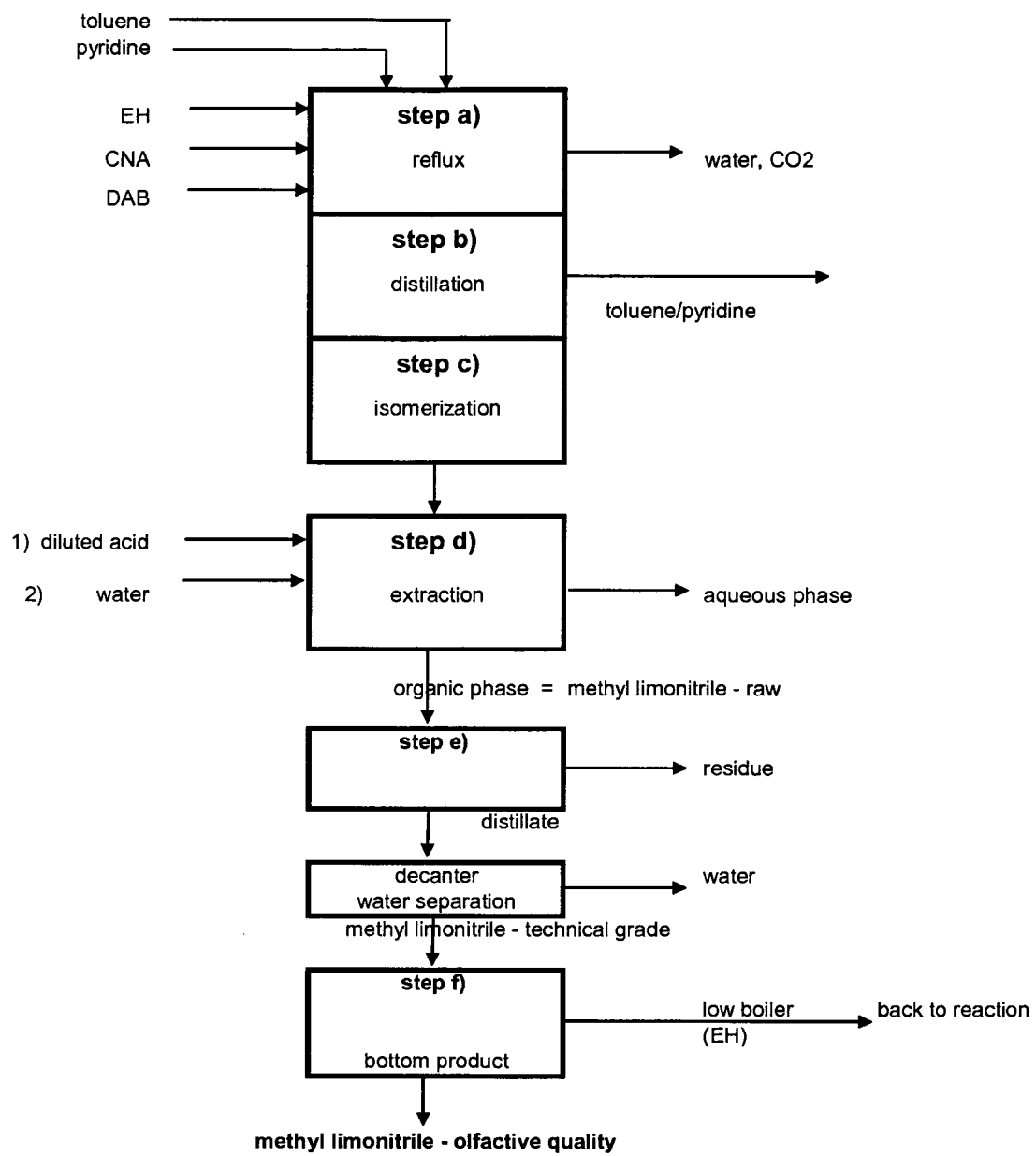


Fig. 7



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/052685

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07C253/30 C07C255/07
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data, BEILSTEIN Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2009/013199 A2 (BASF SE [DE]; WEIS MARTINE [DE]; BRUNNER BERNHARD [DE]; EBEL KLAUS [DE] 29 January 2009 (2009-01-29) page 17 - page 18; examples 1-2 -----	1-19



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search

5 April 2013

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2013/052685

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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