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PROCESS FOR THE CONDENSATION OF

HYDROGEN CYANIDE WITH AN ALDEHYDE

The present invention relates to a process
for the condensation of hydrogen cyanide with an
5 aldehyde.

It is known, for example from US patent
4,518,801, to prepare methionine by hydrolysis of 5-(β -
methylmercaptoethyl)hydantoin in the presence of 0.3 to
5 equivalents of alkaline hydroxide, of alkaline
10 carbonate or of a mixture thereof, then to separate the
alkaline methioninate obtained from salts coproduced
during the hydrolysis and, lastly, to hydrolyse the
alkaline salt obtained to methionine. The hydantoin is
prepared by contact between the cyanohydrin of
15 methylthiopropionic aldehyde, ammonia and carbon
dioxide.

It is also known, for example from US patent
4,960,932, to prepare methionine by a process
comprising four steps. In a first step, methylthio- α -
20 hydroxybutyronitrile is prepared by condensation of
methylthiopropionic aldehyde and hydrogen cyanide in
the presence of triethylamine. Next, in a second step,
the methylthio- α -hydroxybutyronitrile is contacted with
ammonia to form methylthio- α -aminobutyronitrile, which
25 is then hydrolysed in a third step in the presence of a
ketone and an alkaline hydroxide to form
methylthiobutyramide, which is finally hydrolysed to
alkaline methioninate and then saponified with an acid.

In the preparation of methylthio- α -hydroxybutyric acid, also referred to as the hydroxy analogue of methionine, the methylthio- α -hydroxybutyronitrile obtained by reaction of

5 methylthiopropionic aldehyde with hydrogen cyanide, in a medium containing pyridine or an amine (see US patent 2,745,745 column 2, lines 52 to 55), is hydrolysed with sulphuric acid to form methylthio- α -hydroxybutyramide as an intermediate and, finally, methylthio- α -

10 hydroxybutyric acid (see EP-B-330,527 or US patent 2,745,745).

The bases used in contacting methylthiopropionic aldehyde with hydrogen cyanide increase the rate of reaction but rapidly bring about

15 degradation of the cyanohydrin formed and of the starting aldehyde, with formation of a highly coloured solution. In addition, the bases are volatile and toxic, which is a great handicap in industrial exploitation since their use requires expensive

20 recycling and safety conditions. In addition to these drawbacks, the volatility of the bases may give rise to local accumulations making the reaction medium very basic in places, thereby giving rise to an increase in coloration, on the one hand by polymerization of the

25 hydrogen cyanide, and on the other hand by degradation of the methylpropionic aldehyde.

It has now been found, quite surprisingly, that the degradation reactions can be reduced and the

condensation reaction promoted if the process is performed in a well-defined pH range and in the absence of the amines which are used in the prior art.

The present invention thus provides a process for the condensation of an aldehyde with hydrogen cyanide in the presence of a buffer which sets the pH

at above 4.0, wherein the process is carried out in the absence of amines and the aldehyde is an aliphatic aldehyde of 1 to 6 carbon atoms optionally substituted by an alkyl, alkoxy or alkylthio group. The pH is preferably set between 4.0 and 6.0, and even more preferably at about 5.

According to a preferred embodiment of the invention, there is provided a process for the condensation of an aldehyde and hydrogen cyanide, in the presence of a buffer which sets the pH at above 4.0, wherein the process is a reactive absorption reaction between liquid aldehyde and gaseous hydrogen cyanide. The buffer is non-volatile and non-toxic, in contrast with the volatile amines used in the prior art.

According to another preferred embodiment of the invention there is provided a process for the condensation of an aldehyde with hydrogen cyanide in the presence of a buffer which sets the pH at above 4.0, wherein the process is a reaction between liquid aldehyde and an aqueous solution of hydrogen cyanide, the aldehyde being an aliphatic aldehyde of 1 to 6 carbon atoms optionally substituted by an alkyl, alkoxy or alkylthio group.

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Among the buffers which make it possible to set the pH, it is preferred to use a buffer chosen from the following mixtures which are mentioned as examples and do not constitute limitations of the invention:

- citric acid and sodium citrate or citric acid and sodium hydroxide;

- phosphoric acid and sodium hydrogen phosphate or phosphoric acid and sodium hydroxide;

- succinic acid and sodium succinate or succinic acid and sodium hydroxide;

- acetic acid and sodium acetate or acetic acid and sodium hydroxide; and

- potassium hydrogen phthalate and sodium hydroxide.

Mixtures of acid and alkaline salts of acid or mixtures of acid and alkaline hydroxide may more
5 generally be used as buffer.

The use of a buffer has the advantage of avoiding degradation of the starting materials and of the desired product, and of neutralizing hydrogen cyanide stabilizing acids such as sulphuric acid.

10 Preferably the aldehyde is an aliphatic aldehyde of 1 to 6 carbon atoms optionally substituted by an alkyl or alkoxy or alkylthio group; it is most particularly preferred to use methylthiopropionic aldehyde.

15 According to a preferred embodiment of the invention, the buffer is prepared in situ by neutralization of citric acid with sodium hydroxide wherein the citric acid/sodium hydroxide molar ratio is between 0.3 and 0.7, and preferably about 0.5.

20 According to a further preferred embodiment of the invention, a gaseous mixture of hydrogen cyanide containing about 7 % by volume of hydrogen cyanide and an aqueous solution of aldehyde are used. The hydrogen cyanide is preferably prepared according to the
25 Andrussow process and is then freed of ammonia contained therein.

According to an alternative preferred embodiment of the invention, an aqueous solution of

hydrogen cyanide in water containing about 20 % by weight of hydrogen cyanide is contacted with aldehyde. In all cases, the molar ratio between the hydrogen cyanide and the aldehyde is preferably in a slight excess with respect to hydrogen cyanide. It is thus preferred to use a molar excess of between 0.1 and 10 %, and even more preferably of between 2 and 5 %.

The buffer used as condensation catalyst is used to set the pH in the desired region; it is preferably used, for example for the citric-citrate buffer, at a molar ratio relative to the aldehyde of between 0.01 and 0.0001 and preferably of about 0.001. It is typically used in aqueous solution such that the cyanohydrin formed is at a weight concentration of about 50 %.

The reaction may be carried out as mentioned above between a gas and a liquid; it is then preferably carried out in a gas-liquid contact device such as:

- a column with plates;
 - a column with packing;
 - a bubble column;
 - a tubular reactor;
 - a drip column;
 - a reactor with a mechanically stirred tank;
- or
- a reactor with a submerged jet.

According to the first of these, which is the preferred one, that is to say when a reactive

absorption column with plates is used, the gas flow containing hydrogen cyanide is introduced at the foot of the plate column and the buffered aqueous solution of aldehyde introduced at the column head. In place of
5 the aqueous solution of aldehyde, it is possible to introduce independent flow inlets at the column head, for example a water inlet, an aqueous buffered solution inlet or an aldehyde solution inlet. It is within the abilities of a person skilled in the art to adapt the
10 number of flows to the device which is used.

An additional washing column is advantageously installed at the head of the reactive absorption column, in order to recover remaining aldehyde and traces of unreacted hydrogen cyanide from
15 the gases leaving the reactive absorption column. This washing column allows exchange between the gases introduced at the foot and the water introduced at the head. For this washing, it is possible to use, for example, columns with plates or with packing. The water
20 recovered at the foot of this column is preferably reintroduced into the reactive absorption column and the purified gases are conveyed to an incinerator.

If the reaction is carried out between an aqueous solution of hydrogen cyanide and the aldehyde,
25 it is preferably performed in a tubular reactor such as an adiabatic piston reactor. In all cases, the reaction is rapid and exothermic.

When the process is performed in a reactive

absorption column, it is preferably carried out at a temperature of between 50 and 100°C and preferably at about 70°C and at atmospheric pressure when performed in an open column. The temperature is regulated by the amount of water introduced with the buffer.

When the process is performed in a tubular reactor the temperature is preferably set between 30 and 110°C and the pressure is preferably between 1 and 10 bar.

The cyanohydrin of the starting aldehyde, obtained by any one of the embodiments of the invention and especially the cyanohydrin of methylthiopropionic aldehyde, is either aminated or treated with a mixture of ammonia and carbon dioxide to lead subsequently to methionine, or is hydrolysed directly to methylthio- α -hydroxybutyric acid.

The present invention will be described more fully with the aid of the examples which follow, which should not be considered as limitations of the invention.

EXAMPLE 1

An Oldershaw column A 50 mm in diameter, 1 metre in height and equipped with 20 perforated plates, and a packed column B of the same diameter, 20 cm in height and equipped with a multiknit packing are used. A schematic representation of this device is attached (see Figure 1/2).

1556.2 g/h of a crude hydrogen cyanide

synthesis gas is introduced into column A via the feed 30, this gas containing by weight:

	- HCN	109.12
	- CH ₄	0.77
5	- CO	88.45
	- CO ₂	33.02
	- H ₂	18.12
	- N ₂	895.46
	- H ₂ O	402.75
10	- various	8.52

Methylthiopropionic aldehyde (MTPA) is introduced into column A at a flow rate of 408.36 g/h via the feed 35, via the feed 41 at the head of column B are introduced 150 g/h of water and via the feed 36 are introduced 4.89 g/h of a mixture of 1.13 g of citric acid and 0.49 g of sodium hydroxide. Condensation of the aldehyde and hydrogen cyanide takes place at pH 5.

1013 g/h of an aqueous solution is collected at the foot of column A, this solution containing:

	- 2-hydroxymethylthiobutyronitrile	514.25
	- HCN	1.54
	- methylthiopropionic aldehyde	0.04
	- H ₂ O	495.85
25	- citric acid	1.13
	- sodium hydroxide	0.49

The gases leaving column A are conveyed to column B at a flow rate of 1531 g/h and exit column B

at a flow rate of 1106 g/h, these gases consisting of:

	- HCN	1.65
	- CH ₄	0.77
	- CO	88.45
5	- CO ₂	33.02
	- H ₂	18.12
	- N ₂	895.46
	- H ₂ O	60.68
	- various	8.52

10 These gases are conveyed to the incinerator.

A feedback flow (flow 44) of 11181.91 g/h of a cooled aqueous solution is set up in column B, towards the head of the said column, this solution containing:

	- HCN	3.90
15	- N ₂	7.72
	- H ₂ O	10434.91
	- methylthiopropionic aldehyde	0.09
	- hydroxymethylthiobutyronitrile	703.59
	- citric acid	22.12
20	- sodium hydroxide	9.59

An aqueous solution having the same composition as the feedback solution of column B is conveyed from an outlet of column B (flow 45) to column A, at a flow rate of 580.06 g/h.

25 EXAMPLE 2

Adjustment of the NaOH/citric acid molar ratio

Example 1 is repeated, modifying the value of pH. The % degree of conversion of the

methylthiopropionic aldehyde is measured, on different plates of the column, as a function of the pH.

	pH 5.6	pH 4.7	pH 3.6	pH 4.5	pH 5.2
2nd plate	50.32	38.31	39.00	47.29	73.92
4th plate	95.74	53.48	47.17	49.82	82.21
5 7th plate	100.00	96.15	70.09	69.86	98.79
9th plate	100.00	99.86	75.76	73.92	99.95
11th plate	100.00	99.94	84.21	84.17	99.99
13th plate	100.00	99.96	90.84	99.63	100.00
15th plate	100.00	99.98	98.48	99.93	100.00
10 17th plate	100.00	100.00	98.30	99.95	100.00
19th plate	100.00	100.00	99.27	99.87	100.00

The hydroxymethylthiobutyronitrile solutions obtained after the reaction are introduced into an oven maintained at 70°C to study the degradation of the nitrile as a function of time. Degradation is estimated by measuring the APHA coloration according to the ISO international standard 2211-1973.

5	Buffer pH	pH 5.6	pH 4.7	pH 3.6	pH 4.5	pH 5.2
	pH of the nitrile	7.2	5.2	3.8	4.7	6.6
	Stoving duration (h)	4	48	48	48/72	72
	APHA coloration before stoving	966	190	300	238	881
	APHA coloration after stoving	17380	1071	1642	333/2837	8769

10 EXAMPLE 3Synthesis of 2-hydroxymethylthiobutyronitrile

The following are loaded with stirring into a 150 ml jacketed glass reactor:

15 methylthiopropionic aldehyde 47.43 g
water 30.97 g

The medium is heterogeneous (2 immiscible liquid phases). 0.6669 g of catalytic solution is added. The catalytic solution is obtained by mixing:

20 NaOH 9 g
citric acid 20.77 g
water 70.30 g

The temperature of the medium establishes at about 20°C. The pH imposed by the catalytic system is in the region of 5.

42.37 g of an aqueous solution of hydrogen cyanide at a concentration of 30.70 % by mass is introduced as quickly as possible via a dropping funnel. The temperature of the reaction medium rises
5 instantaneously to 70°C. This corresponds to the heat of reaction. The temperature level (70°C) is maintained in the reaction mass for a period of 5 min by circulating a hot fluid through the jacket.

The pH remains at about 5 throughout the
10 reaction. After this time spent at 70°C, it was verified that the yield of the reaction for the synthesis of methylthiobutyronitrile relative to the methylthiopropionic aldehyde is 100 %.

The reaction medium became homogeneous as
15 soon as the temperature and the level of conversion of the methylthiopropionic aldehyde reached a sufficient level.

EXAMPLE 4

Methylthiopropionic aldehyde is condensed
20 continuously, in an adiabatic reactor, with an aqueous solution of hydrogen cyanide at a concentration of 20 %. This solution is prepared from liquid 100 % hydrogen cyanide and water. The reaction catalyst is added straight into the water. According to the
25 schematic representation of Figure 2/2, the water is introduced at a flow rate of 1941 kg/h ① the citric acid/sodium citrate catalyst at a flow rate of 10 kg/h

②, the 20 % solution of hydrogen cyanide at a flow rate of 398 kg/h ③ and the methylthiopropionic aldehyde ④ at a flow rate of 1444 kg/h.

The catalytic solution ② is prepared by

5 adding 390 g of aqueous 50 % sodium hydroxide and 450 g of anhydrous citric acid into 1340 g of water. The pH of the solution is adjusted to 5.0 ± 0.2 by adding one or other of the two reactants.

The hydroxymethylthiobutyronitrile formed

10 reacts with ammoniacal waters ⑤ which are introduced at a flow rate of 8400 kg/h. These ammoniacal waters contain 13.7 % by mass of carbon dioxide, 9.7 % by mass of ammonia and water. The hydantoin formed is hydrolysed with an aqueous solution of sodium hydroxide
15 at a concentration of 50 % by weight, which is introduced at a flow rate of 2310 kg/h ⑥. The sodium methioninate is hydrolysed to methionine by the action of 98 % sulphuric acid, which is introduced at ⑦ at a flow rate of 2890 kg/h. An aqueous solution containing
20 15 % of methionine by weight is collected at ⑧ at a flow rate of 1986 kg/h. The yield of methionine relative to the methylthiopropionic aldehyde is 96.0 %.

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CLAIMS

1. A process for the condensation of an aldehyde with hydrogen cyanide in the presence of a buffer which
5 sets the pH at above 4.0, wherein the process is carried out in the absence of amines and the aldehyde is an aliphatic aldehyde of 1 to 6 carbon atoms optionally substituted by an alkyl, alkoxy or alkylthio group.
- 10 2. A process according to claim 1, wherein the pH is set between 4.0 and 6.0.
3. A process according to claim 1 or 2, wherein the buffer is non-volatile.
- 15 4. A process according to claim 1, wherein the buffer is chosen from:
 - citric acid and sodium citrate or citric acid and sodium hydroxide;
 - 20 - phosphoric acid and sodium hydrogen phosphate or phosphoric acid and sodium hydroxide;
 - succinic acid and sodium succinate or succinic acid and sodium hydroxide;
 - acetic acid and sodium acetate or acetic acid
25 and sodium hydroxide; and
 - potassium hydrogen phthalate and sodium hydroxide.
5. A process according to any one of claims 1 to 4
30 wherein the aldehyde is methylthiopropionic aldehyde.
6. A process for the condensation of an aldehyde and hydrogen cyanide, in the presence of a buffer which

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sets the pH at above 4.0, wherein the process is a reactive absorption reaction between liquid aldehyde and gaseous hydrogen cyanide.

5 7. A process according to claim 6, wherein the reactive absorption reaction takes place in a gas-liquid contact device chosen from:

- a column with plates;
- a column with packing;
- 10 - a bubble column;
- a tubular reactor;
- a drip column;
- a reactor with a mechanically stirred tank; and
- 15 - a reactor with a submerged jet.

8. A process according to claim 6 or 7, wherein the device is a reactive absorption column with plates and a washing column is added to the head of the reactive
20 absorption column.

9. A process for the condensation of an aldehyde with hydrogen cyanide in the presence of a buffer which sets the pH at above 4.0, wherein the process is a
25 reaction between liquid aldehyde and an aqueous solution of hydrogen cyanide, the aldehyde being an aliphatic aldehyde of 1 to 6 carbon atoms optionally substituted by an alkyl, alkoxy or alkylthio group.

30 10. A process according to claim 10, wherein the reaction takes place in an adiabatic piston reactor.

11. A product formed by condensation of hydrogen

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cyanide and an aldehyde when prepared by a process as claimed by any one of claims 1 to 10.