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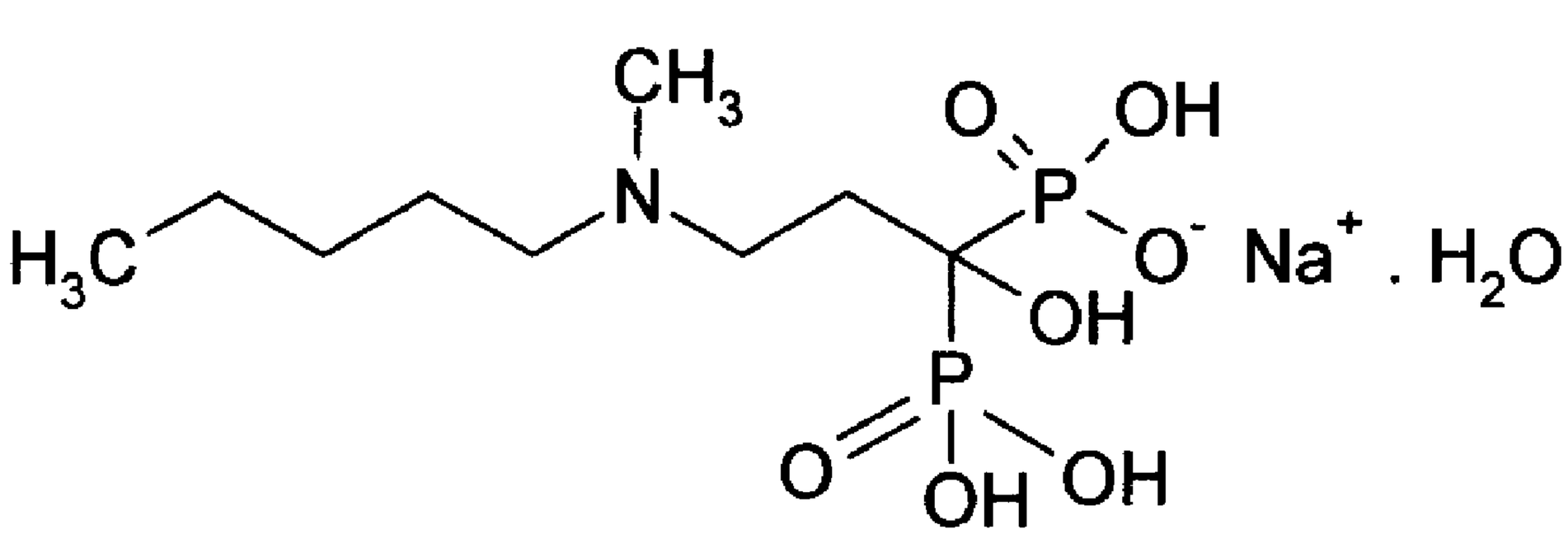
(54) Titre : METHODE DE PREPARATION DE BISPHOSPHONATES
(54) Title: PROCESS FOR THE PREPARATION OF BISPHOSPHONATES



(I)

(57) Abrégé/Abstract:
The invention relates to a novel multi step synthesis of 3-(N-methyl-N-pentyl) amino-l-hydroxypropane-1, 1-diphosphonic acid, monosodium salt, monohydrate, of Formula (I).

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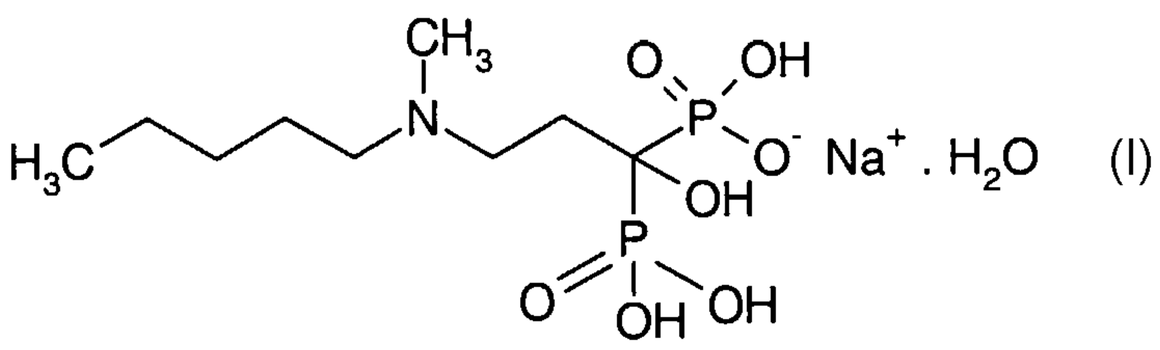
(54) Title: PROCESS FOR THE PREPARATION OF IBANDRONATE

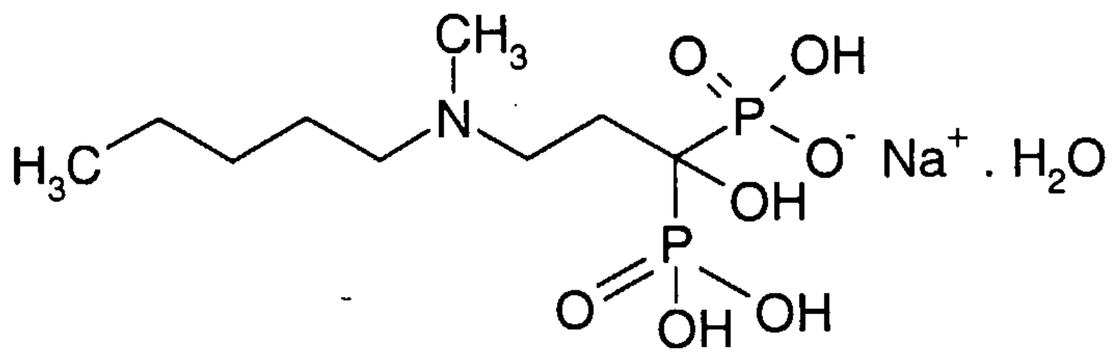


(I)

(57) Abstract: The invention relates to a novel multi step synthesis of 3-(N-methyl-N-pentyl) amino-lhydroxypropane-1, 1-diphosphonic acid, monosodium salt, monohydrate, of Formula (I).

Process for the preparation of Bisphosphonates

The present invention relates to a process for the preparation of 3-(N-methyl-N-pentyl) amino-1-hydroxypropane-1, 1-diphosphonic acid, monosodium salt, monohydrate (Ibandronate) with the following formula



I

Ibandronate is one of the most potent antiresorptive drugs that directly inhibit osteoclast activity and present an effective pharmacologic alternative for controlling hypercalcemia. Ibandronate binds to hydroxyapatite in calcified bone, rendering it resistant to hydrolytic dissolution by phosphatases, thereby inhibiting both normal and abnormal bone resorption. This drug increases bone mass and decreases the risk of fractures and is therefore particularly well adapted to bone and calcium metabolic diseases such as for instance osteoporosis or Paget's disease (EP-A 0252504).

For the preparation of Ibandronate the following processes are known in the state of the art and have been considered.

For example, EP 0402152 discloses the preparation of crystalline 4-amino -1-hydroxybutyllidene-1-bisphosphonic acid monosodium trihydrate, carried out in one step in presence of phosphorus trihalide, phosphorous acid and methane sulfonic acid. This process allows the reaction mixture to remain fluid.

WO 03/097655 discloses the preparation of a bisphosphonic acid including the step of combining a carboxylic acid with phosphorous acid and phosphoryl chloride in the presence of a diluent. The said diluent includes aromatic hydrocarbons such as toluene, xylene and benzene or inert silicone fluids such as polydimethylsiloxane and polymethylphenylsiloxane.

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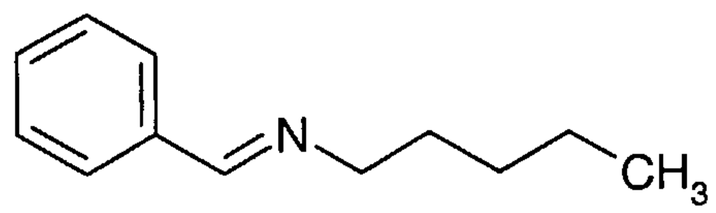
However, the methods described in the art are not satisfactory with regard to yield and purity.

Object of the present invention therefore was to find a new process for producing Ibandronate with high yields and with little residual by-products.

It has been found that the object could be achieved with the process of the present invention which comprises:

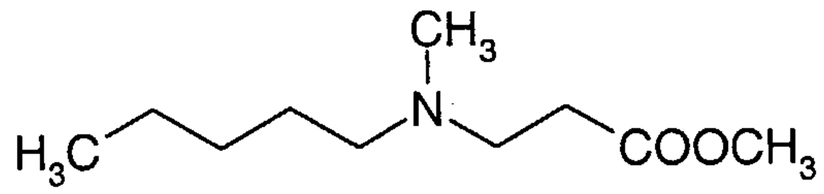
(a) condensation of N-pentylamine with benzaldehyde to produce the N-benzylidene-N-pentylamine of formula II



II

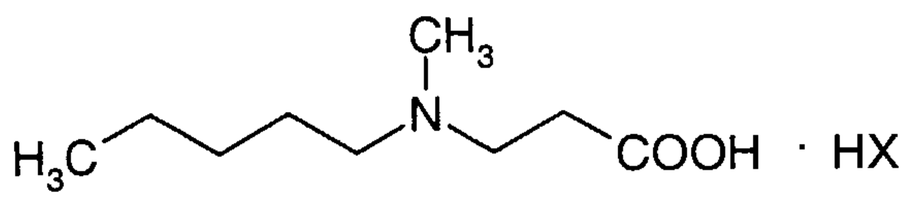
(b) transformation of the N-benzylidene–N-pentylamine into the N-methyl-N-pentylamine with a methylating agent

(c) conversion of the N-methyl-N-pentylamine with methyl acrylate into the N-methyl-N-pentyl-β-alanine methylester of the formula III



III

(d) hydrolysis of N-methyl-N-pentyl-β-alanine methyl ester and subsequent formation of the hydrohalogenide to produce the compound of the formula IV



IV

wherein X is a halogen,

(e) bisphosphorylation of the compound of formula IV by means of phosphoryl chloride and phosphorous acid and after addition of sodium hydroxide formation of the monosodium salt, monohydrate.

The first step a) of the process of the present invention comprises the condensation of N-pentylamine with benzaldehyde to produce the N-benzylidene-N-pentylamine of formula II.

This condensation can be carried out in a suitable solvent such as aliphatic alcohols, at a reaction temperature of 40°C to 90°C, preferably in methanol at 70°C to 75°C.

The second step b) of the process of the present invention comprises the transformation of the N-benzylidene–N-pentylamine into the N-methyl-N-pentylamine with a methylating agent.

Methylating agents such as methyl halogenides or dimethyl sulfate, but preferably dimethyl sulfate is used. The reaction as a rule takes place at a temperature of 80°C to 110°C, preferably at 90°C to 100°C. The generated benzaldehyde can optionally be removed by steam distillation and the resulting N-methyl-N-pentylamine can be isolated from the aqueous phase by any means known to the skilled in the art such as by addition of a base and extraction of the basic solution with a suitable organic solvent such as an aliphatic ether, preferably with diisopropylether. The product can be further purified for instance by distillation.

In a third step (c) of the process of the present invention the N-methyl-N-pentylamine is converted with methyl acrylate into the N-methyl-N-pentyl-β-alanine methylester of the formula III.

This conversion can be carried out in a suitable solvent such as an aliphatic alcohol, an aliphatic ether or an ether/alcohol mixture, but preferably in methanol at a reaction temperature of 10°C to 65°C, preferably at 15°C to 25°C. Isolation of the N-methyl-N-pentyl-β-alanine methyl ester can be performed by techniques known to the skilled in the art such as by distillation.

In step (d) of the process of the present invention the hydrolysis of N-methyl-N-pentyl-β-alanine methyl ester and subsequent formation of the hydrohalogenide takes place to produce the compound of the formula IV.

The hydrolysis is usually performed by refluxing the N-methyl-N-pentyl-β-alanine methyl ester in a diluted mineral acid, but preferably in water at least until no educt ester can be detected any further. Subsequent formation of the hydrohalogenide such as the

hydrobromide or the hydrochloride, preferably of the hydrochloride (X=Cl) is as a rule effected by addition of an aqueous solution of hydrochloric acid. The resulting N-methyl-N-pentyl-β-alanine hydrochloride can be isolated by distilling of the water and by a crystallization of the residue in a suitable solvent such as toluene/acetone or methyl ethyl ketone, preferably in methyl ethyl ketone.

Step (e) of the present invention comprises the bisphosphorylation of the compound of formula IV by means of phosphoryl chloride and phosphorous acid and the formation of the monosodium salt, monohydrate.

The bisphosphorylation of the N-methyl-N-pentyl-β-alanine hydrochloride may take place either in the presence of a non aromatic solvent or with no solvent present. It is preferred to use a non aromatic solvent.

Suitable non aromatic solvents are phosphoric acid esters, phosphonic acid esters or carbonic acid esters. Preferred solvent is diethylcarbonate.

As phosphorylating agent a mixture of phosphoryl chloride and phosphorous acid is used. The molar ratio N-methyl-N-pentyl-β-alanine hydrochloride / phosphoryl chloride / phosphorous acid is a rule selected from 1 : 3 : 3 to 1 : 1,4 : 2,4, preferably 1 : 1,6 : 2,4 to 1: 1,4 : 2,4

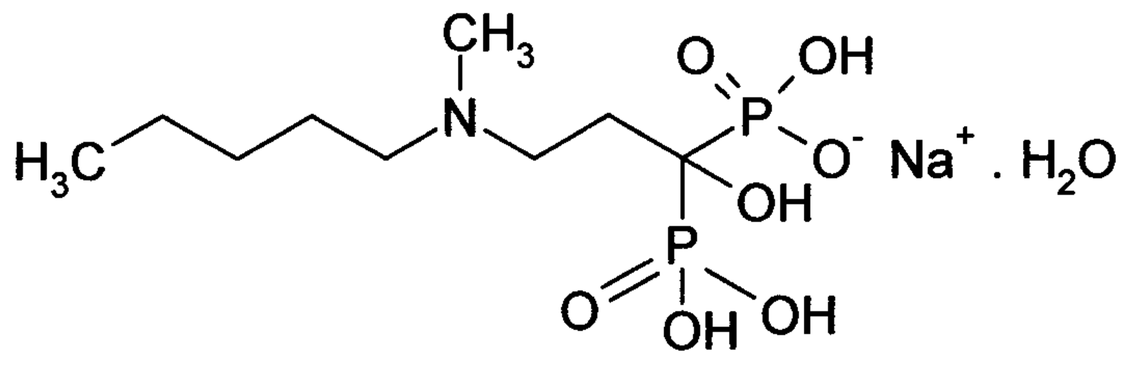
During the bisphosphorylation the reaction temperature is expediently maintained in a range of from 60°C to 100°C, preferably 80°C to 90°C.

In case a non aromatic solvent is used it is ideally removed by addition of water and subsequent azeotropic distillation.

In order to isolate the monosodium salt, monohydrate of the 3-(N-methyl-N-pentyl) amino-1-hydroxypropane-1, 1-diphosphonic acid the pH of the remaining aqueous reaction mixture is adjusted to a pH from about 3,5 to 6, preferably from 4,4 to 4,5 with an aqueous solution of sodium hydroxide at a temperature in the range of about 20°C to 25°C.

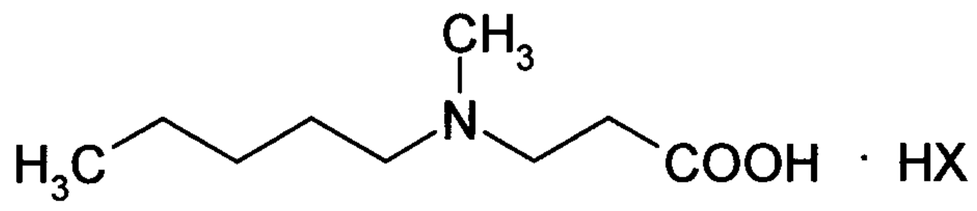
The Ibandronate so obtained can be crystallized in suitable solvents such as aliphatic alcohols/water or aliphatic ketones/water, preferably in ethanol/water and aceton/water.

A further object of the present invention is to provide a process for the preparation of 3-(N-methyl-N-pentyl) amino-1-hydroxypropane-1, 1-diphosphonic acid, monosodium salt, monohydrate of the formula I



I

which process comprises the bisphosphorylation of the compound of formula IV



IV

wherein X is a halogen,

by means of phosphoryl chloride and phosphorous acid and the formation of the monosodium salt, monohydrate.

The preferred embodiments of this process are described in step e) as above.

The process of the present invention allows to produce the 3-(N-methyl-N-pentyl) amino-1-hydroxypropane-1, 1-diphosphonic acid, monosodium salt, monohydrate of the formula I in excellent yield and quality.

Examples:

a) Preparation of N-benzylidene-N-pentylamine

100 g (1, 15 mol) N-pentylamine was added to 200 ml methanol at a temeperature of 22°C. 121, 8 g (1, 15 mol) benzaldehyde was added. The mixture was refluxed and subsequently, methanol was distilled off. The residual N-benzylidene-N-pentylamine 199,8 g (99, 4 %) was used in the next step.

b) Preparation of N-methyl-N-pentylamine

60 g (475,7 mmol) dimethyl sulfate and 67 g (382,2 mmol) N-benzylidene-N-pentylamine were stirred at a temperature of 90-100°C and 117 ml purified water was added to the mixture. The generated benzaldehyde was removed by steam distillation. 133 ml diisopropyl ether and 54 ml sodium hydroxide solution (50 %) were added. The aqueous layer was separated. Diisopropyl ether was distilled off. 3, 3 g sodium hydroxide flakes are added to the residue to bind residual water. The residue, crude N-methyl-N-pentylamine was purified by distillation (29, 4 g; 76 %).

c) Preparation of N-methyl-N-pentyl-β-alanine methyl ester

106 g (1, 05 mol) N-methyl-N- pentylamine was added to cooled methanol of a temperature of 0-5°C. 108 g (1, 25 mol) methyl acrylate was added to the solution and the mixture was stirred at room temperature for 8 hours. Then methanol was distilled off in vacuo and the residue was purified by distillation to obtain 188, 6 g N-methyl-N-pentyl-β-alanine methyl ester (96, 1 %)

d) Preparation of N-methyl-N-pentyl-β-alanine hydrochloride

68, 8 g (367, 4 mmol) N-methyl-N-pentyl-β-alanine methyl ester was hydrolyzed by refluxing with 138 ml water. Then the water is partly distilled off and 83 ml (472, 7 mmol) hydrochloric acid (19 %) was added. Water was distilled off again and 230 ml methyl ethyl ketone was added to remove residual water by azeotropic distillation. The reaction mixture was then cooled to 24°C. The crystallized product was separated and washed with methyl ethyl ketone and subsequently dried in vacuo. 63, 7 g (82, 7%) N-methyl-N-pentyl-β-alanine hydrochloride were obtained.

e1) Preparation of 3-(*N*-methyl-*N*-pentyl) amino-1-hydroxypropane-1, 1-diphosphonic acid, monosodium salt, monohydrate, in presence of diethyl carbonate as diluent.

250 g (1, 19 mol) N-methyl-N-pentyl-β-alanine hydrochloride, 233 g (2, 84 mol) phosphorous acid, 151 ml (1, 65 mol) phosphoryl chloride and 900 ml diethylcarbonate were heated stepwise to 80°C. After 2 hours reaction time under continued heating the mixture was cooled to 60°C and 1733 ml water were added, followed by azeotropic distillation of diethylcarbonate/ water at 90 to 101°C. 358 ml water was added, the mixture was refluxed and water was distilled off. 316 ml water were added and water was distilled off twice. Finally 2040 ml water were added and the residue was cooled to 24 °C. The pH was adjusted at 23°C with sodium hydroxide solution (50%) to 4.4. Thereafter, 1100 ml ethanol were added to start crystallization. The suspension was stirred for 8 hours at 21 to 22°C. Then the solid was separated, washed with 344 ml cold ethanol/purified water (7/5 V/V), subsequently with 344 ml acetone/purified water (5/2 V/V) and dried at 60°C.
315, 6 g (73.7%) of the title product were obtained in the form of colorless crystals.

Assay (complexometric titration): 100, 6 %

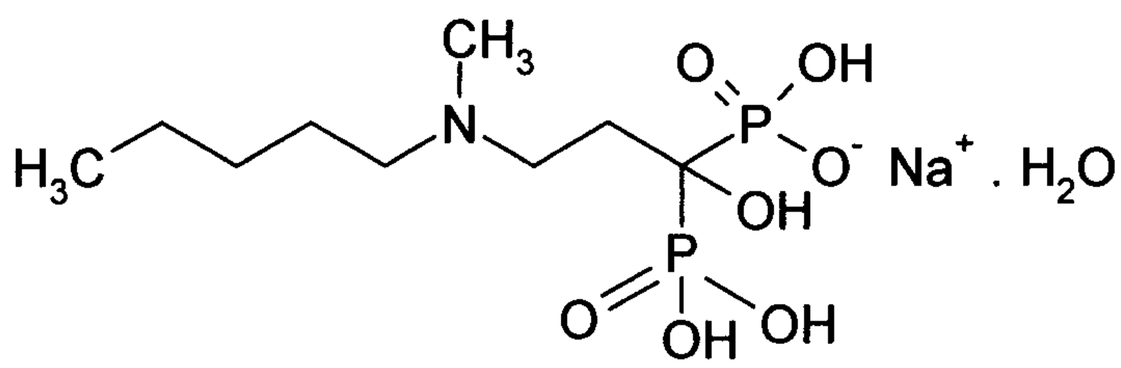
e2) Preparation of 3-(*N*-methyl-*N*-pentyl) amino-1-hydroxypropane-1, 1-diphosphonic acid, monosodium salt, monohydrate.

36, 3 g (172, 8 mmol) N-methyl-N-pentyl-β-alanine hydrochloride, 33, 9 g (413, 2 mmol) phosphorous acid, 22, 75 ml (248,6 mmol) phosphoryl chloride were heated stepwise to 80°C. After 2 hours reaction time under continued heating the mixture was cooled to 60°C and 251, 7 ml water were added. The mixture was refluxed and water was distilled off. 46 ml water were added and water was distilled off twice. 296, 5 ml water were added and the residue was cooled to 24 °C. The pH was adjusted with sodium hydroxide solution (50%) to 4.5 at 23°C. Thereafter, 159, 7 ml ethanol were added to start crystallization. The suspension was stirred for 8 hours at 21-22°C. Then the solid was separated, washed with 90 ml cold ethanol/purified water (3/2V/V), subsequently with 90 ml acetone/purified water (5/2 V/V) and dried at 60°C.
42, 6 g (68, 6 %) of the title product were obtained in the form of colorless crystals.

Assay (complexometric titration): 99, 8 %

Claims

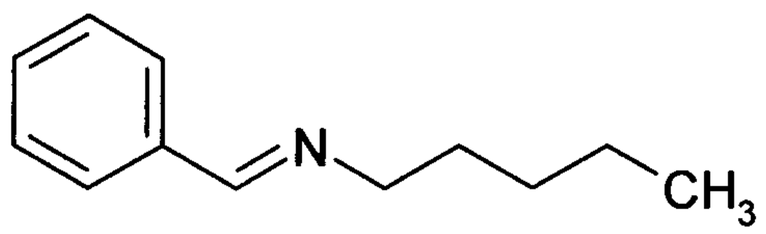
1. A process for the preparation of 3-(N-methyl-N-pentyl)amino-1-hydroxypropane-1,1-diphosphonic acid, monosodium salt, monohydrate of the formula I



I

said process comprising:

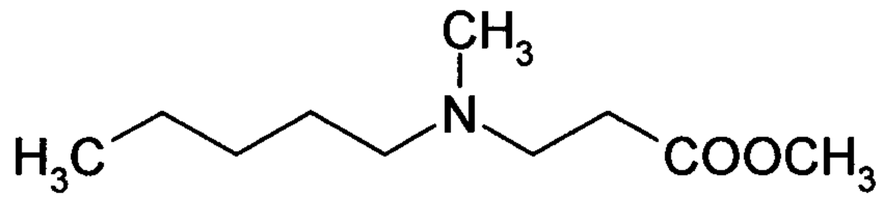
(a) condensation of N-pentylamine with benzaldehyde to produce the N-benzylidene-N-pentylamine of formula II



II

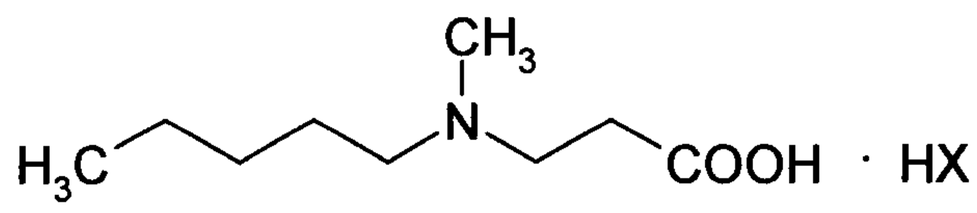
(b) transformation of the N-benzylidene–N-pentylamine into the N-methyl-N-pentylamine with a methylating agent

(c) conversion of the N-methyl-N-pentylamine with methyl acrylate into the N-methyl-N-pentyl-β-alanine methylester of the formula III



III

(d) hydrolysis of N-methyl-N-pentyl-β-alanine methyl ester and subsequent formation of the hydrohalogenide to produce the compound of the formula IV



IV

wherein X is a halogen,

(e) bisphosphorylation of the compound of formula IV by means of phosphoryl chloride and phosphorous acid in a non aromatic solvent and by the formation of the monosodium salt, monohydrate.

2. Process according to claim 1, wherein the condensation in step a) is performed in a suitable solvent at a temperature of 40°C to 90°C.

3. Process according to claim 1 or 2, wherein the transformation in step b) is performed at a temperature of 80°C to 110°C.

4. Process according to any one of claims 1 to 3, wherein the transformation in step b) is performed with dimethyl sulfate as methylating agent.

5. Process according to any one of claims 1 to 4, wherein the conversion in step c) is performed in a suitable solvent at a reaction temperature of 10°C to 65°C.

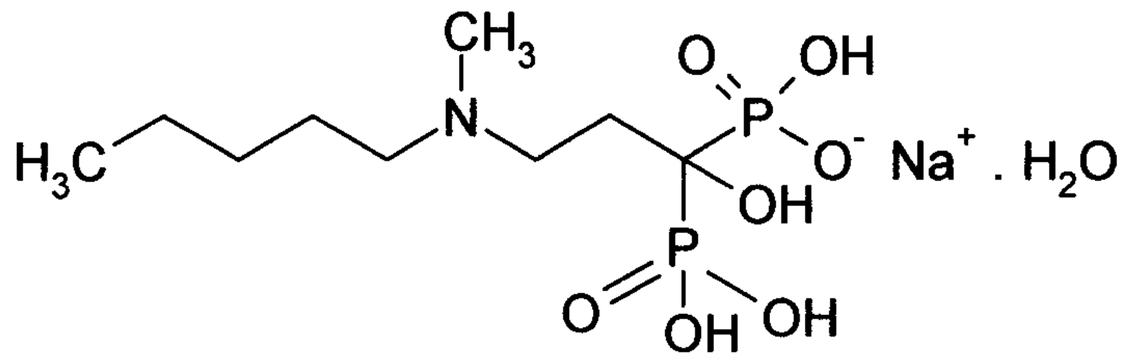
6. Process according to any one of claims 1 to 5, wherein the solvent is diethyl carbonate.

7. Process according to any one of claims 1 to 6, wherein in the bisphosphorylation in step e) the molar ratio N-methyl-N-pentyl-β-alanine hydrochloride / phosphoryl chloride / phosphorous acid is selected from 1 : 3 : 3 to 1 : 1.4 : 2.4.

8. Process according to any one of claims 1 to 7, wherein in the bisphosphorylation in step e) the reaction temperature is selected from 60°C to 100°C.

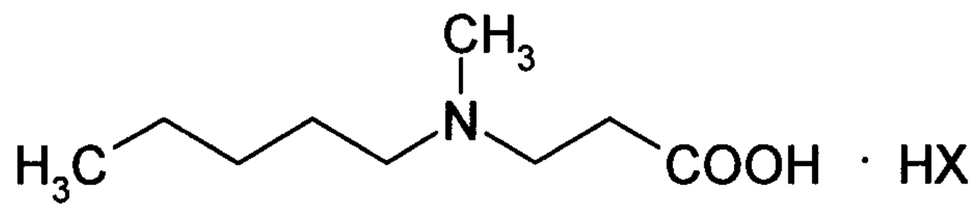
9. Process according to any one of claims 1 to 8, wherein the formation of the monosodium salt, monohydrate is effected by adjusting the pH of the aqueous reaction mixture to about 3.5 to 6, with an aqueous solution of sodium hydroxide.

10. A process for the preparation of 3-(N-methyl-N-pentyl)amino-1-hydroxypropane-1,1-diphosphonic acid, monosodium salt, monohydrate of the formula I



I

said process comprising bisphosphorylation of the compound of formula IV



IV

wherein X is a halogen,

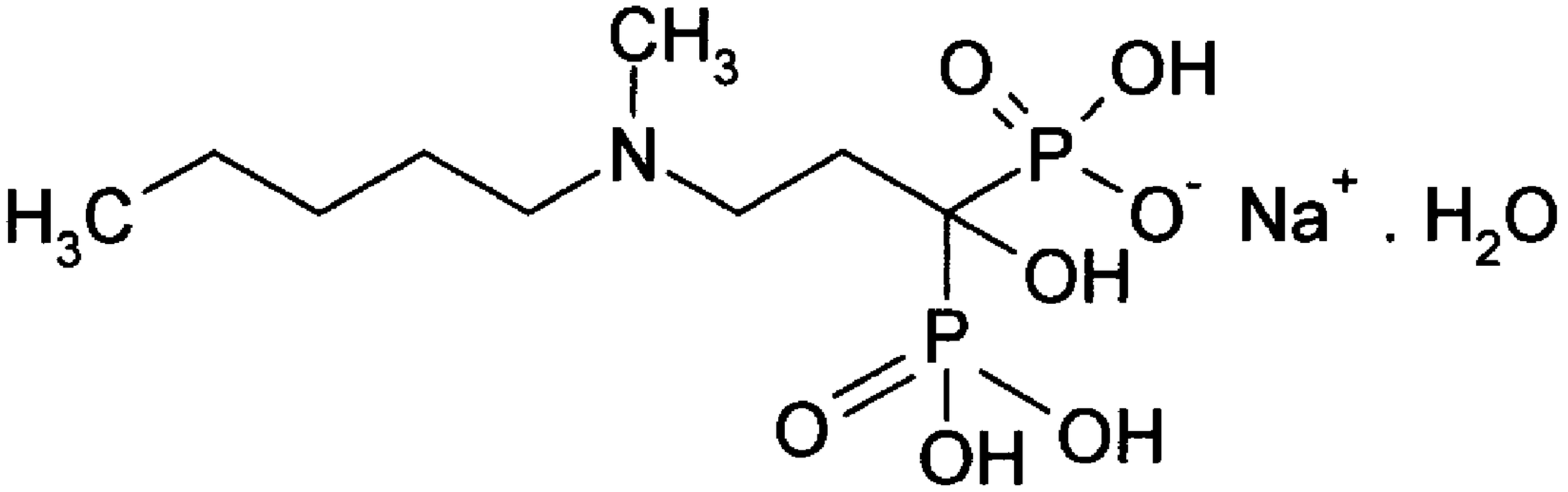
by means of phosphoryl chloride and phosphorous acid in a non aromatic solvent and by the formation of the monosodium salt, monohydrate.

11. Process according to claim 10, wherein the solvent is diethyl carbonate.

12. Process according to claim 10 or 11, wherein the molar ratio N-methyl-N-pentyl-β-alanine hydrochloride / phosphorous oxychloride / phosphorus acid is selected from 1 : 3 : 3 to 1 : 1.4 : 2.4.

13. Process according to any one of claims 10 to 12, wherein the bisphosphorylation is performed at a reaction temperature of 60°C to 100°C.

14. Process according to any one of claims 10 to 13, wherein the formation of the monosodium salt, monohydrate is effected by adjusting the pH of the aqueous reaction mixture to about 3.5 to 6, with an aqueous solution of sodium hydroxide.


CH3
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