

DESCRIPTION

Title of Invention: METHOD FOR PRODUCING METHIONINE AND/OR 2-HYDROXY-4- (METHYLTHIO) BUTANOIC ACID

5 Technical Field

[0001]

The present invention relates to a method for producing methionine and/or 2-hydroxy-4- (methylthio)butanoic acid using 3- (methylthio)propionaldehyde as a raw material.

10

Background Art

[0002]

Methionine and 2-hydroxy-4- (methylthio)butanoic acid (which may hereinafter also be referred to as "liquid methionine") are both useful as an additive for animal feed. Methionine and liquid methionine are produced by using 3- (methylthio)propionaldehyde as a raw material.

15

[0003]

As a method for producing methionine, for example, Patent Document 1 discloses a method for obtaining methionine, the method comprising obtaining 2-hydroxy-4- (methylthio)butanenitrile by reacting 3- (methylthio)propionaldehyde with hydrogen cyanide in the presence of a base, then reacting the resulting 2-hydroxy-4- (methylthio)butanenitrile with ammonium carbonate to give 5-(β -methylmercaptoethyl)hydantoin, followed by hydrolysis in the presence of a basic potassium compound to obtain methionine.

20

[0004]

Patent Document 2 discloses a method for producing methionine at a high yield, the method comprising obtaining 2-amino-4- (methylthio)butanenitrile by reacting 3- (methylthio)propionaldehyde, hydrogen cyanide, and ammonia, and contacting the obtained 2-amino-4- (methylthio)butanenitrile with water in the presence of an oxide catalyst containing cerium.

30

[0005]

35

As a method for producing liquid methionine, for example, Patent Document 3 discloses a method for obtaining liquid methionine, the method comprising reacting 3-(methylthio)propionaldehyde with hydrogen cyanide, followed by
5 hydrolysis of the resulting 2-hydroxy-4-(methylthio)butanenitrile in the presence of sulfuric acid.

Citation List

Patent Documents

10 [0006]

Patent Document 1: JP2010-111642A

Patent Document 2: WO2016/047516

Patent Document 3: Japanese Patent No. 3932757

15 Summary of Invention

Problem to be Solved by the Invention

[0007]

All of the methods for producing methionine and liquid methionine disclosed in Patent Documents 1 to 3 had problems to
20 be solved, such as a high operation cost and high facility cost due to multiple manufacturing steps. Therefore, an object of the present invention is to provide a simple method for producing methionine and/or 2-hydroxy-4-(methylthio)butanoic acid at a high yield using 3-(methylthio)propionaldehyde as a raw material.

25

Means for Solving the Problem

[0008]

The inventor of the present invention carried out extensive research, and found that, by contacting an oxide
30 catalyst containing cerium; 3-(methylthio)propionaldehyde; a compound containing cyanide ion; ammonia or a compound containing ammonium ion; and water with each other, it is possible to produce methionine and/or 2-hydroxy-4-(methylthio)butanoic acid at a high yield with a single-stage reaction from 3-
35 (methylthio)propionaldehyde. With further consideration based on

this finding, the inventor completed the present invention.

[0009]

More specifically, the present invention encompasses the following items.

5

[1] A method for producing methionine and/or 2-hydroxy-4-(methylthio)butanoic acid, comprising contacting an oxide catalyst containing cerium, 3-(methylthio)propionaldehyde, a compound containing cyanide ion, ammonia or a compound containing ammonium ion, and water with each other.

10

[2] The method according to Item [1], wherein the oxide catalyst containing cerium is at least one oxide selected from cerium oxides and oxide solid solutions containing cerium.

15

[3] The method according to Item [1] or [2], wherein the compound containing cyanide ion is hydrogen cyanide.

[4] The method according to any one of Items [1] to [3], wherein ammonia or the compound containing ammonium ion is at least one member selected from aqueous ammonia, liquid ammonia, and ammonia gas.

20

[5] The method according to any one of Items [1] to [4], wherein the reaction temperature is 40 to 110°C.

[6] The method according to any one of Items [1] to [5], wherein the oxide catalyst containing cerium, 3-(methylthio)propionaldehyde, hydrogen cyanide, ammonia, and water are contacted with each other in a single vessel.

25

[7] The method according to any one of Items [1] to [6], wherein the oxide catalyst containing cerium and 3-(methylthio)propionaldehyde are contacted with each other in the presence of the compound containing cyanide ion and ammonia or the compound containing ammonium ion.

30

[8] The method according to any one of Items [1] to [7], wherein, after the oxide catalyst containing cerium, the compound containing cyanide ion, ammonia or the compound containing ammonium ion, and water are mixed, the mixture is mixed with 3-(methylthio)propionaldehyde.

35

Advantageous Effects of Invention

[0010]

The production method of the present invention enables
5 simple production of methionine and/or 2-hydroxy-4-
(methylthio)butanoic acid at a high yield using 3-
(methylthio)propionaldehyde as a raw material.

[0011]

In contrast to the previously-known methods for
10 producing methionine or liquid methionine that required two or
more manufacturing steps (Patent Documents 2 and 3), the
production method of the present invention may be performed with
a single manufacturing step; therefore, the handleability can be
significantly increased, and the operation and facility costs may
15 be greatly reduced.

[0012]

Further, the present inventors had uniquely found the
following improvements over the methionine production method
requiring two manufacturing steps (Patent Document 2).
20 Specifically, in the previously-known method, a separation device
and a storage facility were required because the liquid
containing 2-amino-4-(methylthio)butanenitrile, which is a
temporarily produced intermediate, was separated into oil and
water; further, since 2-amino-4-(methylthio)butanenitrile is
25 unstable both thermally and over time, by-products were
unavoidably generated due to decomposition. However, since the
production method of the present invention may be performed with
a single manufacturing step, the separation device and the
storage facility are not necessary, and the generation of by-
30 products may be greatly reduced, thereby obtaining the desired
methionine and/or 2-hydroxy-4-(methylthio)butanoic acid at a high
yield.

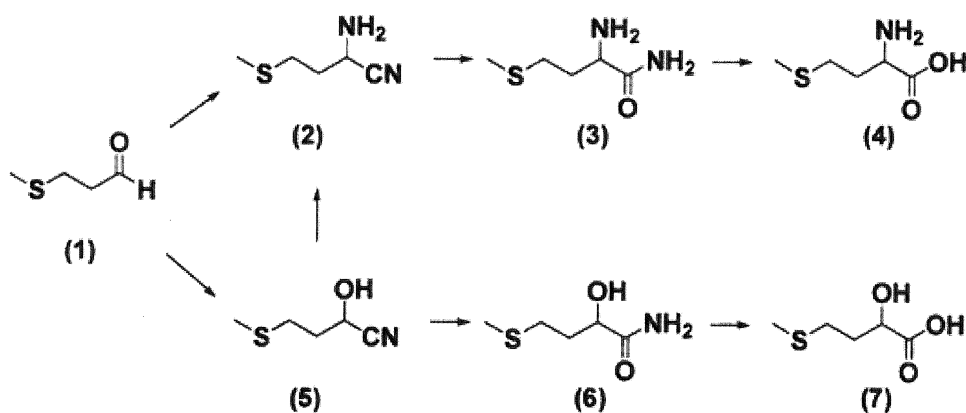
Description of Embodiments

35 [0013]

The production method of the present invention comprises contacting an oxide catalyst containing cerium; 3-(methylthio)propionaldehyde; a compound containing cyanide ion; ammonia or a compound containing ammonium ion; and water, with
5 each other, thereby producing methionine and/or 2-hydroxy-4-(methylthio)butanoic acid at a high yield with a single manufacturing step from 3-(methylthio)propionaldehyde.
[0014]

In the production method of the present invention, the
10 reaction path in the reaction system from 3-(methylthio)propionaldehyde (1) as a raw material to methionine (4) and/or 2-hydroxy-4-(methylthio)butanoic acid (7) as target products with a single manufacturing step is as follows.
[0015]

15 Reaction Formula



[0016]

The methionine (4) production path is such that 2-amino-4-(methylthio)butanenitrile is first produced from the raw
20 material, i.e., 3-(methylthio)propionaldehyde (1); 2-amino-4-(methylthio)butanamide (3) is subsequently produced by hydration; and then methionine (4) is produced by hydrolysis.
[0017]

The 2-hydroxy-4-(methylthio)butanoic acid (7)
25 production path is such that 2-hydroxy-4-(methylthio)butanenitrile (5) is first produced from the raw

material, i.e., 3-(methylthio)propionaldehyde (1); 2-hydroxy-4-(methylthio)butanamide (6) is subsequently produced by hydration; and then 2-hydroxy-4-(methylthio)butanoic acid (7) is produced by hydrolysis.

5 [0018]

The production method of the present invention enables production of the target products, i.e., methionine (4) and/or 2-hydroxy-4-(methylthio)butanoic acid (7) at a high yield with a single manufacturing step from the raw material, i.e., 3-(methylthio)propionaldehyde (1).

10 [0019]

Since the production method of the present invention may be performed with a single manufacturing step, compared with previously-known methods that required two or more manufacturing steps, the handleability can be significantly increased, and the operation and facility costs may be greatly reduced. In particular, the production method of the present invention is significantly useful in the production of methionine (4) and/or 2-hydroxy-4-(methylthio)butanoic acid (7) in an industrial scale.

15 Further, since the production method of the present invention does not perform an operation for obtaining a liquid containing 2-amino-4-(methylthio)butanenitrile (2), a separation device and a storage facility are not necessary, and therefore it is economical.

20 [0020]

Still further, since the production method of the present invention enables the production of the target compound, i.e., methionine (4) and/or 2-hydroxy-4-(methylthio)butanoic acid (7), without obtaining 2-amino-4-(methylthio)butanenitrile (2), it is possible to greatly reduce the generation of by-products, thereby obtaining the target compound at a high yield.

30 [0021]

In the production method of the present invention, as shown in the reaction formula above, 2-amino-4-(methylthio)butanamide (3) and 2-hydroxy-4-(methylthio)butanamide

(6), which are precursors (intermediates) of methionine (4) and/or 2-hydroxy-4-(methylthio)butanoic acid (7), are generated in some cases. The compounds (3) and (6) may be reduced by adjusting the reaction time, the reaction temperature, or the like (generally, by increasing the reaction temperature and prolonging the reaction time), thereby facilitating the reaction. Alternatively, the compounds (3) and (6) may be separated from the target compounds (4) and (7) after the reaction, and recycled in the production method of the present invention. As is clear from the above, the compounds (3) and (6) may be regarded as useful components (hereinafter referred to as "valuable components") as precursors (intermediates) of the target compounds (4) and (7).

[0022]

The production method of the present invention generally yields a mixture of methionine (4) and 2-hydroxy-4-(methylthio)butanoic acid (7). Since methionine (4) and 2-hydroxy-4-(methylthio)butanoic acid (7) exhibit similar effects as a feed additive, they are useful both alone and as a mixture.

[0023]

Methionine (4) and 2-hydroxy-4-(methylthio)butanoic acid may be separated and/or purified from the above mixture. The separation and/or purification methods are not particularly limited, and examples include crystallization, condensation, extraction, distillation, oil/water separation, neutralization, filtration, chromatography, and the like.

[0024]

For example, by removing an oxide catalyst containing cerium (in particular, cerium oxide) from a reaction fluid containing the mixture, condensing and cooling the reaction fluid to crystallize methionine, and filtering the crystal, followed by washing, a solid of methionine (4) is obtained. By recrystallizing the solid as necessary, methionine (4) having high purity is obtained. Further, by condensing the filtrate obtained by filtration, 2-hydroxy-4-(methylthio)butanoic acid (7)

having a high concentration is obtained.

[0025]

The oxide catalyst containing cerium (Ce) used in the present invention contains, for example, an oxide containing
5 cerium (Ce) (e.g., cerium oxide, oxide solid solution or mixed oxide containing cerium, etc.). Examples thereof also include catalysts in which other components are supported by the oxide containing cerium that serves as a support and catalysts in which
10 the oxide containing cerium is supported by a support. Among these oxide catalysts containing cerium (Ce), cerium oxide and oxide solid solutions containing cerium are preferable, and cerium oxide is most preferable.

[0026]

Examples of cerium oxide include cerium(III) oxide
15 (Ce_2O_3), cerium(IV) oxide (CeO_2), and mixed phases thereof; among these, cerium(IV) oxide CeO_2 is preferable.

[0027]

Examples of the oxide solid solution containing cerium include $\text{CeO}_2\text{-ZrO}_2$ (ceria-zirconia), $\text{CeO}_2\text{-Y}_2\text{O}_3$, $\text{CeO}_2\text{-La}_2\text{O}_3$, and the
20 like. The component to be solid-soluted with cerium oxide is not limited, and it may contain three or more metals. Among these, ceria-zirconia is most preferable.

[0028]

Examples of the mixed oxide containing cerium include
25 CeAlO_3 , CeGaO_3 , CeFeO_3 , CeCrO_3 , CeScO_3 , MgCeO_3 , CaCeO_3 , SrCeO_3 , BaCeO_3 and the like. Each metal element may be partially replaced by another element.

[0029]

In the oxide catalyst containing cerium, the content of
30 cerium is, as the content of cerium(IV) oxide, preferably 5 to 100 wt%, more preferably 30 to 100 wt%, further preferably 70 to 100 wt%, and most preferably 95 to 100 wt%.

[0030]

The oxide catalyst containing cerium may be used by
35 being mixed with other catalysts. The other catalysts are not

particularly limited, and examples include zirconium oxide, magnesium oxide, zinc oxide, titanium oxide, and like oxides; and hydrotalcite and like clay minerals. Among these, zirconium oxide is preferable. In this case, the content of oxide catalyst
5 containing cerium is preferably 50 to 100 wt% in the entire catalyst.

[0031]

As the oxide catalyst containing cerium, two or more catalysts different in composition and physical property (form,
10 particle size, etc.) may be used in combination. The average primary particle size of the oxide containing cerium in the oxide catalyst containing powdery cerium is preferably 500 nm or less, more preferably 100 nm less, and further preferably 20 nm or less; preferably 0.5 nm or more, and more preferably 1 nm or
15 more. The average primary particle size of the catalyst is measured using a transmission electron microscope (TEM), a scanning electron microscope (SEM), or a like electron microscope.

[0032]

20 The oxide catalyst containing cerium may be any commercially available catalyst, or may be produced according to or by referring to a known method. The oxide catalyst containing cerium may be prepared, for example, by a method of calcining a precursor containing a cerium compound under an atmosphere of
25 oxidizing gases, such as air. Examples of cerium compounds include halides, inorganic salts (e.g., sulfates, nitrates, carbonates, phosphates), acetates, oxalates, hydroxides, and the like, of cerium.

[0033]

30 The oxide catalyst containing cerium may be activated by heating using an oxidizing gas, such as air, an inert gas, such as nitrogen or argon, a reducing gas, such as hydrogen, carbon dioxide, or steam. The heating temperature is not particularly limited, the heating temperature is preferably 200
35 to 1200°C, and more preferably 400 to 1100°C.

[0034]

The form of the oxide catalyst containing cerium is not particularly limited. A catalyst processed into a formed product, such as a pellet or the like, may be used if necessary. The
5 formed product may be prepared, for example, by a method comprising adding water or the like to a powdery compound containing cerium, and a solid support, which may be used if necessary, thereby obtaining a paste, then obtaining a formed product such as a pellet-like formed product through extrusion,
10 and calcining the resulting extruded product.

[0035]

The amount of the oxide catalyst containing cerium is, in a cerium amount, generally 0.001 to 5 moles, more preferably 0.01 to 3 moles, further preferably 0.02 to 1.5 moles, per mole
15 of 3-(methylthio)propionaldehyde.

[0036]

Examples of compounds containing cyanide ion include hydrogen cyanide, sodium cyanide, potassium cyanide, silver cyanide, copper cyanide, zinc cyanide, ammonium cyanide, and the
20 like. One or more compounds among these compounds may be used. Of these, in terms of being free of metal ions and no need for separation and removal of metal ions in the subsequent step, hydrogen cyanide and ammonium cyanide are preferable, and hydrogen cyanide is most preferable. Hydrogen cyanide may be
25 supplied as a liquid, may be blown into a liquid as a gas, or may be supplied as an aqueous solution.

[0037]

The amount of the compound containing cyanide ion is generally 0.01 to 100 moles, more preferably 0.9 to 10 moles,
30 most preferably 1.0 to 3 moles, per mole of 3-(methylthio)propionaldehyde.

[0038]

Examples of ammonia or the compound containing ammonium ion include aqueous ammonia, liquid ammonia, ammonia gas,
35 ammonium carbonate, ammonium hydrogen carbonate, ammonium

acetate, ammonium formate, ammonium nitrate, ammonium sulfate, ammonium fluoride, ammonium chloride, ammonium bromide, ammonium iodide, ammonium dihydrogenphosphate, ammonium borate, ammonium tartrate, ammonium oxalate, and the like. One or more substances
5 among these substances may be used. Among these, aqueous ammonia, liquid ammonia, or ammonia gas is preferable, and aqueous ammonia is most preferable in terms of easy handling.

[0039]

The amount of ammonia or the compound containing
10 ammonium ion is generally 0.01 to 100 moles, per mole of 3-(methylthio)propionaldehyde. The amount of ammonia or the compound containing ammonium ion is preferably greater to obtain a greater amount of methionine (4). The amount is preferably 1.5 to 100 moles, more preferably 2 to 10 moles (e.g., see Example
15 3). In contrast, the amount of ammonia or the compound containing ammonium ion is preferably smaller to obtain a greater amount of 2-hydroxy-4-(methylthio)butanoic acid (7). The amount is preferably 0.01 to 1.5 moles (e.g., see Example 2).

[0040]

20 The amount of water (when aqueous ammonia or the like is used as a raw material, the amount also includes water contained in the raw material) is generally 2 to 1000 moles, more preferably 5 to 100 moles, and most preferably 10 to 50 moles, per mole of 3-(methylthio)propionaldehyde.

25 [0041]

The production method of the present invention generally uses water in the solvent amount; however, as necessary, an organic solvent, which may be mixed or not mixed with water, may be used. Examples of the solvents to be mixed
30 with water include methanol, ethanol, isopropanol, or like alcohol solvents, 1,4-dioxane, tetrahydrofuran, or like ether solvents, acetonitrile, acetone, dimethylsulfoxide, N-methylpyrrolidinone, N-ethylpyrrolidinone, 1,3-dimethyl-2-imidazolidinone, and the like.

35 [0042]

In the production method of the present invention, an oxide catalyst containing cerium, 3-(methylthio)propionaldehyde, a compound containing cyanide ion, ammonia or a compound containing ammonium ion, and water are contacted with each other.

5 The procedures for contacting or mixing the components are explained below. For example, it is possible that, after the oxide catalyst containing cerium is mixed with water, the compound containing cyanide ion and ammonia or the compound containing ammonium ion are added, and, finally, 3-
10 (methylthio)propionaldehyde is added. Further, it is also possible that, after the compound containing cyanide ion is mixed with ammonia or the compound containing ammonium ion, the oxide catalyst containing cerium is added, then 3-
15 (methylthio)propionaldehyde is added, and, finally, water is added. Further, it is also possible that the oxide catalyst containing cerium is added to 3-(methylthio)propionaldehyde, water is added thereto, then ammonia or the compound containing ammonium ion is added, and the compound containing cyanide ion is mixed.

20 [0043]

Among these, to obtain methionine and 2-hydroxy-4-(methylthio)butanoic acid at a high yield, it is preferable to determine the order of supplying the oxide catalyst containing cerium and 3-(methylthio)propionaldehyde so that they are
25 contacted with each other in the presence of the compound containing cyanide ion and ammonia or the compound containing ammonium ion (in particular, the compound containing cyanide ion).

[0044]

30 This is because, when the oxide catalyst containing cerium and 3-(methylthio)propionaldehyde are contacted with each other in the absence of the compound containing cyanide ion and ammonia or the compound containing ammonium ion, the catalyst is poisoned and deactivated by the aldehyde; as a result, when the
35 compound containing cyanide ion and ammonia or the compound

containing ammonium ion are subsequently supplied, the reactivity is low, thereby decreasing the yield of the target compounds (4) and (7).

[0045]

5 Therefore, the order of addition is preferably such that, for example, after the oxide catalyst containing cerium, the compound containing cyanide ion, ammonia or the compound containing ammonium ion, and water are mixed, the mixture is mixed with 3-(methylthio)propionaldehyde.

10 [0046]

 Further, to increase the yield of methionine (4), the order of addition is preferably such that, after the oxide catalyst containing cerium is mixed with ammonia or the compound containing ammonium ion and the compound containing cyanide ion, 15 the mixture is mixed with 3-(methylthio)propionaldehyde. More specifically, for example, by mixing the oxide catalyst containing cerium with water, subsequently adding the compound containing cyanide ion thereto, further adding ammonia or the compound containing ammonium ion, and, finally, adding 3- 20 (methylthio)propionaldehyde, it is possible to obtain methionine at a high yield.

[0047]

 Further, to increase the yield of 2-hydroxy-4-(methylthio)butanoic acid (7), the order of addition is 25 preferably such that, after the oxide catalyst containing cerium is mixed with the compound containing cyanide ion and 3-(methylthio)propionaldehyde, the mixture is mixed with ammonia or the compound containing ammonium ion. More specifically, for example, by mixing the oxide catalyst containing cerium with 30 water, subsequently adding the compound containing cyanide ion thereto, further adding 3-(methylthio)propionaldehyde, and, finally, adding ammonia or the compound containing ammonium ion, it is possible to obtain 2-hydroxy-4-(methylthio)butanoic acid at a high yield. An example is shown in Example 4.

35 [0048]

Generally, the step of mixing the oxide catalyst containing cerium, 3-(methylthio)propionaldehyde, the compound containing cyanide ion, ammonia or the compound containing ammonium ion, and water may be performed in a single vessel.

5 Generally, after the mixing, the reaction is performed in the same reaction vessel. Alternatively, after the mixing in a vessel, the resulting mixture may be transferred to a different reaction vessel to be subjected to a reaction. Further, it is also possible that two or more components selected from the oxide
10 catalyst containing cerium, 3-(methylthio)propionaldehyde, the compound containing cyanide ion, ammonia or the compound containing ammonium ion, and water, are first mixed, and the mixture is then supplied to a vessel to be mixed with the rest of the compounds. For example, it is possible that the oxide
15 catalyst containing cerium is first mixed with water, and then the mixture is supplied to a vessel, or that the compound containing cyanide ion and ammonia or ammonium ion are mixed first and then the mixture is supplied to a vessel.

[0049]

20 The reaction may be performed after 3-(methylthio)propionaldehyde, the compound containing cyanide ion, ammonia or the compound containing ammonium ion, and water are mixed. The reaction temperature is generally 0 to 300°C, preferably 0 to 150°C, and most preferably 40 to 110°C. The
25 reaction may be performed under an increased pressure as necessary, preferably at 0.1 to 2 MPa, and more preferably at 0.2 to 0.5 MPa, based on absolute pressure. Further, the reaction conditions, such as temperature, pressure, and the like, may be changed stepwise or successively during the reaction. This
30 manufacturing step may be performed in any of a continuous reactor, a semicontinuous reactor, and a batch reactor.

[0050]

The catalyst in which the activity is decreased by the reaction may be reused after being separated from the reaction
35 mass and regenerated. As a method for regeneration, washing or

heat treatment can be adopted. Washing can be performed with, for example, water, acid, alkali, an organic solvent, and the like. A heat treatment is usually performed under the atmosphere of an oxidizing gas, such as air, an inert gas such as nitrogen or
5 argon, a reducing gas such as hydrogen, carbon dioxide, steam, or the like. Of these, the heat treatment is preferably performed under the atmosphere of an oxidizing gas. Further, the temperature of the heat treatment is preferably 200 to 800°C, and more preferably 300 to 600°C. These methods of washing and heat
10 treatment may be combined.

Examples

[0051]

The present invention is described in more detail below
15 with reference to Examples. However, the present invention is not limited only to these Examples.

[0052]

Example 1

12.1 g of cerium oxide (Daiichi Kigenso Kagaku Kogyo
20 Co., Ltd.) and 60.8 g of water were placed in a three-necked flask equipped with a stirrer and a thermometer, and the mixture was cooled to 10°C or lower in an ice bath; thereafter, 5.7 g of hydrogen cyanide, 35.0 g of 28 wt% aqueous ammonia, and 20.1 g of 3-(methylthio)propionaldehyde were successively added, and the
25 mixture was stirred in a water bath for six hours at 75°C. Thereafter, the mixture was cooled, and the cerium oxide was removed by a membrane filter, followed by washing with water. The resulting reaction fluid was analyzed by liquid chromatography. The results revealed that the conversion of 3-
30 (methylthio)propionaldehyde was 100%, that the yield of methionine was 48.0%, and that the yield of 2-hydroxy-4-(methylthio)butanoic acid was 49.6%. Further, as for the intermediates, the yield of 2-amino-4-(methylthio)butanamide was 0.6%, and the yield of 2-hydroxy-4-(methylthio)butanamide was
35 1.7%.

[0053]

Example 2

12.1 g of cerium oxide (Daiichi Kigenso Kagaku Kogyo Co., Ltd.) and 74.6 g of water were placed in a three-necked
5 flask equipped with a stirrer and a thermometer, and the mixture was cooled to 10°C or lower in an ice bath; thereafter, 5.7 g of hydrogen cyanide, 15.2 g of 28 wt% aqueous ammonia, and 20.0 g of 3-(methylthio)propionaldehyde were successively added, and the mixture was stirred in a water bath for six hours at 75°C.
10 Thereafter, the mixture was cooled, and the cerium oxide was removed by a membrane filter, followed by washing with water. The resulting reaction fluid was analyzed by liquid chromatography. The results revealed that the conversion of 3-(methylthio)propionaldehyde was 100%, that the yield of
15 methionine was 36.6%, and that the yield of 2-hydroxy-4-(methylthio)butanoic acid was 58.5%. Further, as for the intermediates, the yield of 2-amino-4-(methylthio)butanamide was 1.3%, and the yield of 2-hydroxy-4-(methylthio)butanamide was 3.5%. In contrast to Example 1, by reducing the amount of
20 ammonia, the yield of 2-hydroxy-4-(methylthio)butanoic acid relative to methionine was increased.

[0054]

Example 3

12.2 g of cerium oxide (Daiichi Kigenso Kagaku Kogyo Co., Ltd.) and 19.7 g of water were placed in a three-necked
25 flask equipped with a stirrer and a thermometer, and the mixture was cooled to 10°C or lower in an ice bath; thereafter, 5.7 g of hydrogen cyanide, 70.0 g of 28 wt% aqueous ammonia, and 20.0 g of 3-(methylthio)propionaldehyde were successively added, and the
30 mixture was stirred in a water bath for six hours at 75°C. Thereafter, the mixture was cooled, and the cerium oxide was removed by a membrane filter, followed by washing with water. The resulting reaction fluid was analyzed by liquid chromatography. The results revealed that the conversion of 3-
35 (methylthio)propionaldehyde was 100%, that the yield of

methionine was 52.6%, and that the yield of 2-hydroxy-4-(methylthio)butanoic acid was 44.3%. Further, as for the intermediates, the yield of 2-amino-4-(methylthio)butanamide was 0.8%, and the yield of 2-hydroxy-4-(methylthio)butanamide was 2.2%. In contrast to Example 1, by increasing the amount of ammonia, the yield of methionine relative to 2-hydroxy-4-(methylthio)butanoic acid was increased.

[0055]

Example 4

12.2 g of cerium oxide (Daiichi Kigenso Kagaku Kogyo Co., Ltd.) and 54.7 g of water were placed in a three-necked flask equipped with a stirrer and a thermometer, and the mixture was cooled to 10°C or lower in an ice bath; thereafter, 5.8 g of hydrogen cyanide, 20.1 g of 3-(methylthio)propionaldehyde, and 34.9 g of 28 wt% aqueous ammonia were successively added, and the mixture was stirred in a water bath for six hours at 75°C. Thereafter, the mixture was cooled, and the cerium oxide was removed by a membrane filter, followed by washing with water. The resulting reaction fluid was analyzed by liquid chromatography. The results revealed that the conversion of 3-(methylthio)propionaldehyde was 100%, that the yield of methionine was 34.9%, and that the yield of 2-hydroxy-4-(methylthio)butanoic acid was 62.1%. Further, as for the intermediates, the yield of 2-amino-4-(methylthio)butanamide was 0.5%, and the yield of 2-hydroxy-4-(methylthio)butanamide was 2.4%.

[0056]

Example 5 (Separation of Methionine and Liquid Methionine)

Cerium oxide was removed from the reaction fluid obtained in Example 3; thereafter, the reaction fluid was condensed and cooled to crystallize methionine. By filtering it with a membrane filter, followed by washing with water, a solid methionine was obtained. The yield of methionine was about 20 to 50% of the raw material, i.e., 3-(methylthio)propionaldehyde. By condensing the filtrate obtained by filtration, a liquid

methionine having a high concentration was obtained.

Table 1

			Example 1	Example 2	Example 3	Example 4
Catalyst			CeO ₂	CeO ₂	CeO ₂	CeO ₂
Reaction Temperature			75	75	75	75
Reaction Time			h	6	6	6
Amount	Ultrapure Water	g	60.8	74.6	19.7	54.7
	Catalyst	g	12.1	12.1	12.2	12.2
	Hydrogen Cyanide	g	5.7	5.7	5.7	5.8
	28 wt% Aqueous Ammonia	g	35.0	15.2	70.0	34.9
	3- (methylthio) propionaldehyde	g	20.1	20.0	20.0	20.1
Conversion of 3- (methylthio)propionaldehyde			%	100.0	100.0	100.0
Yield	(1) Methionine	%	48.0	36.6	52.6	34.9
	(2) 2-hydroxy-4- (methylthio)butanoic acid	%	49.6	58.5	44.3	62.1
	(3) 2-amino-4- (methylthio)butanamide	%	0.6	1.3	0.8	0.5
	(4) 2-hydroxy-4- (methylthio)butanamide	%	1.7	3.5	2.2	2.4
	Final Product ((1) + (2))	%	97.6	95.1	96.9	97.0
	Valuable Components ((1) to (4))	%	99.9	99.9	99.9	99.9

5 Industrial Applicability

[0057]

The production method of the present invention enables simple production of methionine and/or 2-hydroxy-4-(methylthio)butanoic acid at a high yield using 3-(methylthio)propionaldehyde as a raw material.

CLAIMS

1. A method for producing methionine and/or 2-hydroxy-4-(methylthio)butanoic acid, comprising contacting an oxide
5 catalyst containing cerium, 3-(methylthio)propionaldehyde, a compound containing cyanide ion, ammonia or a compound containing ammonium ion, and water with each other.
2. The method according to claim 1, wherein the oxide
10 catalyst containing cerium is at least one oxide selected from cerium oxides and oxide solid solutions containing cerium.
3. The method according to claim 1 or 2, wherein the
15 compound containing cyanide ion is hydrogen cyanide.
4. The method according to any one of claims 1 to 3,
wherein ammonia or the compound containing ammonium ion is at
least one member selected from aqueous ammonia, liquid ammonia,
and ammonia gas.
20
5. The method according to any one of claims 1 to 4,
wherein the reaction temperature is 40 to 110°C.
6. The method according to any one of claims 1 to 5,
25 wherein the oxide catalyst containing cerium, 3-(methylthio)propionaldehyde, hydrogen cyanide, ammonia, and water are contacted with each other in a single vessel.
7. The method according to any one of claims 1 to 6,
30 wherein the oxide catalyst containing cerium and 3-(methylthio)propionaldehyde are contacted with each other in the presence of the compound containing cyanide ion and ammonia or the compound containing ammonium ion.
- 35 8. The method according to any one of claims 1 to 7,

wherein, after the oxide catalyst containing cerium, the compound containing cyanide ion, ammonia or the compound containing ammonium ion, and water are mixed, the mixture is mixed with 3-(methylthio)propionaldehyde.