layers is regulated to $Sn \leq 6$.

B) The method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid as set forth in A),

wherein at least one of the plurality of catalyst layers is regulated to $Sn \leq 3$.

C) The method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid as set forth in A) or B),

wherein N is 2 or 3.

D) The method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid as set forth in any one of A) to C),

wherein a concentration of the alkene in a raw material is 7 to 12% by volume.

E) The method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid as set forth in any one of A) to D),

wherein all of the catalyst layers contain a complex metal oxide having a formulation represented by the following formula (1):

Formula (1)

$$Mo_{12}Bi_aFe_bCo_cNi_dX_eY_fZ_gO_h$$

(X is at least one element selected from the group consisting of magnesium (Mg), calcium (Ca), manganese (Mn), copper (Cu), zinc (Zn), cerium (Ce) and samarium (Sm); Y is at least one element selected from the group consisting of boron (B), phosphorus (P), arsenic (As), antimony (Sb) and tungsten (W); Z is at least one element selected from the group consisting of sodium (Na), potassium (K), rubidium (Rb) and cesium (Cs); a to g represent atomic ratios of the respective components; h is a numerical value determined by degrees of oxidations of the catalyst components; a = 0.80 to 2.0, b = 1 to 3; c = 3 to 7; d = 2 to 4; e = 0 to 10; f = 0 to 10; g = 0.01 to 0.10; h is expressed by the numerical value satisfying the oxidation states of other elements; d/a is 1.9 or more and 3.2 or less; d/g is 29 or more and 69 or less; and a/g is 18 or more and 39 or less.)

Effects of Invention

[0007]

According to the present invention, in using, as a raw material, an alkene or an alcohol capable of producing an alkene through its intramolecular dehydration reaction to produce a corresponding unsaturated aldehyde or unsaturated carboxylic acid, it becomes possible to keep

oxide-containing gas, an ammonia-containing gas, a hydrogen gas, or a mixture thereof for the purpose of rendering the system into a reducing atmosphere. There is thus obtained a catalyst (E).

[0016]

Although the catalyst contained in all of the catalyst layers of the fixed bed multitubular reactor which is used for the method of the present invention is not particularly limited, a catalyst containing a complex metal oxide having a formulation represented by the following formula (1) is preferred.

[0017]

$$Mo_{12}Bi_aFe_bCo_cNi_dX_eY_fZ_gO_h \qquad (1)$$

[0018]

(X is at least one element selected from the group consisting of magnesium (Mg), calcium (Ca), manganese (Mn), copper (Cu), zinc (Zn), cerium (Ce) and samarium (Sm); Y is at least one element selected from the group consisting of boron (B), phosphorus (P), arsenic (As), antimony (Sb) and tungsten (W); Z is at least one element selected from the group consisting of sodium (Na), potassium (K), rubidium (Rb) and cesium (Cs); a to g represent atomic ratios of the respective components; h is a numerical value determined by degrees of oxidations of the catalyst components; a = 0.80 to 2.0, b = 1 to 3; c = 3 to 7; d = 2 to 4; e = 0 to 10; f = 0 to 10; g = 0.01 to 0.10; h is expressed by the numerical value satisfying the oxidation states of other elements; d/a is 1.9 or more and 3.2 or less; d/g is 29 or more and 69 or less; and a/g is 18 or more and 39 or less.)

[0019]

In the complex metal oxide having the formulation represented by the foregoing formula (1), more preferably, b = 1 to 2.5, d = 2 to 3.5, and a/g is 18 or more and 35 or less.

[0020]

The catalytic gas-phase oxidation reaction of an alkene in the present invention is carried out by introducing a mixed gas composed of 7 to 12% by volume of an alkene, 5 to 18% by volume of molecular oxygen, 0 to 60% by volume of steam, and 20 to 70% by volume of an inert gas, for example, nitrogen, carbon dioxide, etc., in terms of a raw material gas formulation onto the catalyst prepared above at a temperature ranging from 250 to 450°C under a pressure of atmospheric pressure to 10 atms, preferably atmospheric pressure to 5 atms, and more preferably atmospheric pressure to 3 atms for a contact time of 0.5 to 10 seconds. It is to be

CLAIMS

[Claim 1]

A method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid, which is a method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid each corresponding to an alkene by partially oxidizing the alkene using a fixed bed multitubular reactor,

wherein a plurality of catalyst layers formed by N division in which N is $N \geq 3$ with respect to a gas flow direction of a reaction tube are provided, and

when a change (°C) of hot spot temperature per 1°C change of reaction bath temperature in the catalyst layer at the time of 300 hours elapsed after a start of reaction and varying the reaction bath temperature is designated as Sn, at least one of the plurality of catalyst layers is regulated to $Sn \leq 6$,

in which the hot spot means a maximum value of the temperatures within the catalyst layers, and is a hot spot within the catalyst layer arranged nearest to a raw material gas inlet side or in the case where no maximum value of the temperatures is present in the catalyst layer arranged nearest to the raw material gas inlet side, a maximum value of the temperatures as a hot spot within the next or subsequent catalyst layer to the catalyst layer arranged nearest to the raw material gas inlet side, and

the reaction bath temperature for determining Sn is set within a range where an alkene conversion is 90% to 99.9%.

[Claim 2]

A method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid, which is a method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid each corresponding to an alkene by partially oxidizing the alkene using a fixed bed multitubular reactor,

wherein a plurality of catalyst layers formed by N division in which N is $N = 3$ with respect to a gas flow direction of a reaction tube are provided, and

when a change (°C) of hot spot temperature per 1°C change of reaction bath temperature in the catalyst layer at the time of 300 hours elapsed after a start of reaction and varying the reaction bath temperature is designated as Sn, at least one of the plurality of catalyst layers is regulated to $Sn \leq 6$,

in which the hot spot means a maximum value of the temperatures within the catalyst layers, and is a hot spot within the catalyst layer arranged nearest to a raw material gas inlet side or in the case where no maximum value of the temperatures is present in the catalyst layer arranged nearest to the raw material gas inlet side, a maximum value of the temperature as a hot spot within the next catalyst layer to the catalyst layer arranged nearest to the raw material gas inlet side, and

the reaction bath temperature for determining Sn is set within a range where an alkene conversion is 90% to 99.9%.

[Claim 3]

A method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid, which is a method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid each corresponding to an alkene by partially oxidizing the alkene using a fixed bed multitubular reactor,

wherein a plurality of catalyst layers formed by N division in which N is N = 2 with respect to a gas flow direction of a reaction tube are provided, and

when a change (°C) of hot spot temperature per 1°C change of reaction bath temperature in the catalyst layer at the time of 300 hours elapsed after a start of reaction and varying the reaction bath temperature is designated as Sn, at least one of the plurality of catalyst layers is regulated to $Sn \leq 6$,

in which the hot spot means a maximum value of the temperatures within the catalyst layers, and is a hot spot within the catalyst layer arranged nearest to a raw material gas inlet side, and

the reaction bath temperature for determining Sn is set within a range where an alkene conversion is 90% to 99.9%.

[Claim 4]

The method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid according to any one of claims 1 to 3,

wherein at least one of the plurality of catalyst layers is regulated to $Sn \leq 3$.

[Claim 5]

The method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid according to any one of claims 1 to 4,

wherein a concentration of the alkene in a raw material is 7 to 12% by volume.

[Claim 6]

The method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid according to any one of claims 1 to 5,

wherein all of the catalyst layers contain a complex metal oxide having a formulation represented by the following formula (1):

Formula (1)

$$Mo_{12}Bi_aFe_bCo_cNi_dX_eY_fZ_gO_h$$

wherein X is at least one element selected from the group consisting of magnesium (Mg), calcium (Ca), manganese (Mn), copper (Cu), zinc (Zn), cerium (Ce) and samarium (Sm); Y is at least one element selected from the group consisting of boron (B), phosphorus (P), arsenic (As), antimony (Sb) and tungsten (W); Z is at least one element selected from the group consisting of sodium (Na), potassium (K), rubidium (Rb) and cesium (Cs); a to g represent atomic ratios of the respective components; h is a numerical value determined by degrees of oxidations of the catalyst components; a = 0.80 to 2.0, b = 1 to 3; c = 3 to 7; d = 2 to 4; e = 0 to 10; f = 0 to 10; g = 0.01 to 0.10; h is expressed by the numerical value satisfying the oxidation states of other elements; d/a is 1.9 or more and 3.2 or less; d/g is 29 or more and 69 or less; and a/g is 18 or more and 39 or less.

[Claim 7]

The method for producing an unsaturated aldehyde and/or an unsaturated carboxylic acid according to claim 6,

wherein b = 1 to 2.5, d = 2 to 3.5, and a/g is 18 or more and 35 or less.