CLAIMS

[Claim 1]

A method for producing an unsaturated aldehyde comprising,

subjecting an alkene to partial oxidation using a fixed bed multi-tube reactor to produce the corresponding unsaturated aldehyde,

wherein two~~n~~ catalyst layers ~~(n is 2 or more)~~ in a gas flow direction in a reaction tube are provided,

when a filling length of the catalyst layer~~s from a first catalyst layer to an (n-1)th catalyst layer from~~ on a gas inlet side of the reaction tube is L, and a filling length of an 2nd ~~nth~~ catalyst layer from the gas inlet side of the reaction tube is Ln, a relationship between L and Ln satisfies the following equation (1):

$$1 < L/Ln \leq 3 \qquad (1),$$ ~~and~~

a composition of a catalytically active component contained in the catalyst layer~~s~~ on ~~from the first catalyst layer to the (n-1)th layer from~~ the gas inlet side of the reaction tube is different from a composition of a catalytically active component contained in the 2nd ~~nth~~ catalyst layer from the gas inlet side of the reaction tube, and

each catalyst layer in the reaction tube contains a catalyst containing a catalytically active component having a composition represented by the following formula (3):

$$Mo_{12}Bi_aFe_bCo_cNi_dX_eY_fZ_gO_h \qquad (3)$$

where 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 an atomic proportion of each component, h is a numerical value determined by a degree of oxidation of a catalyst component, a = 0.40 to 2.0, b = 1 to 3, c = 3 to 7.5, d = 2 to 4, e = 0 to 10, f = 0 to 10, g = 0.01 to 0.50, h is a numerical value for satisfying oxidation states of the other elements, d/a is 1 or more and 9 or less, d/g is 5 or more and 350 or less, and a/g is 0.8 or more and 90 or less.

[Claim 2]

The method for producing an unsaturated aldehyde according to claim 1, wherein the relationship between L and Ln satisfies the following equation (2):

$$1.1 < L/Ln \leq 1.4 \qquad (2).$$

[Claim 3]

The method for producing an unsaturated aldehyde according to claim 1 or 2, wherein a catalyst contained in the catalyst layer has a spherical shape.

[Claim 4]

The method for producing an unsaturated aldehyde according to any one of claims 1 to 3, wherein a concentration of the alkene in a raw material is 6 vol% to 12 vol%.

~~[Claim 5]~~

~~The method for producing an unsaturated aldehyde according to any one of claims 1 to 4, wherein each catalyst layer in the reaction tube contains a catalyst containing a catalytically active component having a composition represented by the following formula (3):~~

~~$Mo_{12}Bi_aFe_bCo_cNi_dX_eY_fZ_gO_h$ (3)~~

~~where 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 an atomic proportion of each component, h is a numerical value determined by a degree of oxidation of a catalyst component, a = 0.40 to 2.0, b = 1 to 3, c = 3 to 7.5, d = 2 to 4, e = 0 to 10, f = 0 to 10, g = 0.01 to 0.50, h is a numerical value for satisfying oxidation states of the other elements, d/a is 1 or more and 9 or less, d/g is 5 or more and 350 or less, and a/g is 0.8 or more and 90 or less.~~

[Claim 5~~6~~]

The method for producing an unsaturated aldehyde according to any one of claims 1 to 4~~5~~, wherein a catalyst contained in the 2nd ~~nth~~ catalyst layer is not diluted with an inert substance.

[Claim 6~~7~~]

The method for producing an unsaturated aldehyde according to any one of claims 1 to 5~~6~~, wherein a catalyst contained in the catalyst layer is a carried catalyst.