28.0° ± 0.3° is defined as IB, a value of IB/IA is 0.08 to 0.5.

By using either of the above-described catalysts, an α,β-unsaturated aldehyde and/or an α,β-unsaturated carboxylic acid can be produced with a high selectivity.

It is noted here that, such an "26.5° ± 0.3°" used herein means a range of "26.5° - 0.3° to 26.5° + 0.3°".

In the present specification, the catalyst according to the first embodiment and the catalyst according to the second embodiment may be distinguished from each other to describe catalyst features; however, these features can be applied to both of the catalysts, including preferred conditions. For example, features of an X-ray diffraction pattern of the catalyst according to the second embodiment are applicable to the catalyst according to the first embodiment, and the features of the bismuth concentration of the catalyst according to the first embodiment are applicable to the catalyst according to the second embodiment. Further, where no special distinction is made between the catalyst according to the first embodiment and the catalyst according to the second embodiment, the term "catalyst" encompasses both of these catalysts.

Moreover, the expression "α,β-unsaturated aldehyde and/or α,β-unsaturated carboxylic acid" used herein can be

paraphrased as "at least one selected from the group consisting of an α,β-unsaturated aldehyde and an α,β-unsaturated carboxylic acid".

[0012]

<Bismuth Concentration in Reflected Electron Image>

The catalyst according to the first embodiment (in this section, also simply referred to as "catalyst") satisfies the above-described Formula (I-1) when a reflected electron image of the catalyst, which is obtained using a scanning electron microscope (SEM) at an accelerating voltage of 15 kV, is binarized into black and white, and an energy dispersive X-ray spectroscopy (EDS) analysis is subsequently performed.

By using this catalyst, an α,β-unsaturated aldehyde and/or an α,β-unsaturated carboxylic acid can be produced with a higher selectivity. With regard to the reason for this, the present inventors presume as follows.

A reflected electron image reflects the atomic numbers of atoms existing on the surface of a sample and the irregular shape of the surface. In such a reflected electron image of the catalyst, those parts having a high concentration of high-atomic-number bismuth are emphasized in white due to the release of a large amount of reflected electrons from the sample. Therefore, when the reflected

simply referred to as "catalyst"), the value of IB/IA is 0.08 to 0.5. Further, when the catalyst satisfies the above-described Formula (I-1), in the X-ray diffraction pattern of the catalyst, a lower limit of IB/IA is preferably 0.08 or more, and an upper limit of IB/IA is preferably 0.5 or less.

The lower limit of IB/IA is more preferably 0.1 or more, still more preferably 0.11 or more, particularly preferably 0.12 or more, most preferably 0.13 or more. The upper limit of IB/IA is more preferably 0.4 or less, still more preferably 0.3 or less.

When the catalyst satisfies the above-described range of IB/IA, an $\alpha,\beta$-unsaturated aldehyde and/or an $\alpha,\beta$-unsaturated carboxylic acid can be produced with a high selectivity. With regard to the reason for this, the present inventors presume as follows.

In the X-ray diffraction pattern, the peak A is a diffraction peak attributed to the (002) plane of a cobalt-containing crystalline phase, and the peak B is a diffraction peak attributed to the (032) plane of a bismuth-containing crystalline phase. The bismuth-containing crystalline phase is believed to function as an active site in an oxidation reaction of a hydrocarbon. It is believed that, therefore, when the value of IB/IA, which is an

passed through the catalyst in the reaction tube for a contact time of 2.7 seconds to evaluate a reaction at a temperature of 330°C. The result thereof is shown in Table 1.

[0061]

<Example 2>

A liquid A was prepared in the same manner as in Example 1. Further, a liquid B was prepared in the same manner as in Example 1, except that the amount of cobalt (II) nitrate hexahydrate was changed to 549.5 parts by mass. Then, the liquid A and the liquid B were mixed to prepare a liquid C.

While circulating the thus obtained liquid C using a circulation pump, a 60-minute dispersion treatment of the liquid C was performed using a stirring-type homogenizer. Subsequently, the resulting dispersion-treated slurry was maintained in the same manner as in Example 1 to prepare a liquid D.

The thus obtained liquid D was dried using a spray dryer to obtain a dry product.

The thus obtained dry product was calcined and molded in the same manner as in Example 1 to obtain a catalyst. This catalyst had an elemental composition of $Mo_{12}Bi_{0.90}Fe_{2.40}Co_{8.0}Sb_{0.70}Cs_{0.50}$, excluding oxygen. For this

obtained values of x1, x2, and σ1 are shown in Table 1.

Using the thus obtained catalyst, a reaction was evaluated in the same manner as in Example 1. The result thereof is shown in Table 1.

[0067]

<Comparative Example 3>

A liquid A' not containing bismuth was prepared by mixing 2,000 parts by mass of 60°C pure water with 500 parts by mass of ammonium paramolybdate tetrahydrate. Further, a liquid B was prepared by mixing 1,000 parts by mass of pure water with 23.0 parts by mass of cesium nitrate, 49.5 parts by mass of bismuth oxide, 24.1 parts by mass of antimony trioxide, 228.8 parts by mass of iron (III) nitrate nonahydrate, and 480.8 parts by mass of cobalt (II) nitrate hexahydrate. Then, the liquid A' and the liquid B were mixed to prepare a liquid C.

The thus obtained liquid C was dispersion-treated and maintained in the same manner as in Example 1 to prepare a liquid D. The thus obtained liquid D was dried using a spray dryer to obtain a dry product.

The resulting dry product was calcined and molded in the same manner as in Example 1 to obtain a catalyst. This catalyst had an elemental composition of $Mo_{12}Bi_{0.90}Fe_{2.40}Co_{7.0}Sb_{0.70}Cs_{0.50}$, excluding oxygen. For this catalyst, X-ray diffraction pattern and bismuth