Claims

[Claim 1]

A catalyst ~~in which~~ for alkane dehydrogenation, wherein a transition metal and carbon are supported on a carrier, and the carbon comprises fibrous carbon,

the transition metal is Ni,

an amount of the carbon based on the transition metal is 1000% by mass or more and 2500% by mass or less, and

a ratio of a crystallite diameter of the transition metal when the carbon comprises the fibrous carbon to a crystallite diameter of the transition metal supported on the carrier when the carbon supported on the carrier does not comprise fibrous carbon is 0.80 or less.

[Claim 2]

The catalyst according to claim 1, wherein a ratio of a crystallite diameter of the transition metal when the carbon comprises the fibrous carbon to a crystallite diameter of the transition metal supported on the carrier when the carbon supported on the carrier does not comprise fibrous carbon is 0.20 or more and 0.50~~0.80~~ or less.

[Claim 3]

The catalyst according to claim 1 or 2, wherein an amount of the carbon based on the transition metal is ~~510~~1000% by mass or more and ~~2500~~2300% by mass or less.

[Claim 4]

The catalyst according to ~~any one of~~ claim~~s~~ 1 ~~to 3~~, wherein ~~the catalyst is a catalyst for alkane dehydrogenation~~an amount of the carbon based on the transition metal is 1000% by mass or more and 2000% by mass or less.

~~[Claim 5]~~

~~The catalyst according to any one of claims 1 to 4, wherein the transition metal is Ni.~~

[Claim ~~6~~5]

The catalyst according to any one of claims 1 to ~~5~~4, wherein the carrier is at least one selected from the group consisting of silica, alumina, zirconia, and titania.

[Claim ~~7~~6]

The catalyst according to any one of claims 1 to ~~5~~4, wherein the carrier is γ-alumina.

[Claim ~~8~~7]

A method for producing a catalyst, comprising:

forming a catalyst precursor by mixing a solution containing a transition metal compound and a carrier, and heating to remove a solvent,

bringing a carbon-containing gas into contact with the catalyst precursor to form a catalyst on which a transition metal and carbon are supported,

wherein in forming the catalyst, a fibrous carbon is formed and supported by bringing the carbon-containing gas into contact with the catalyst precursor,

the transition metal is Ni,

a ratio of a crystallite diameter of the transition metal supported on the catalyst to a crystallite diameter of the transition metal on the catalyst precursor when the carbon-containing gas is not brought into contact is 0.80 or less, and

the catalyst is a catalyst for producing an unsaturated hydrocarbon by bringing a mixed gas comprising an alkane and carbon dioxide into contact with the catalyst.

[Claim ~~9~~8]

The method for producing a catalyst according to claim ~~8~~7, wherein the step of forming the catalyst precursor comprises a step of forming a solid by mixing a solution in which a transition metal compound is dissolved and a carrier, and heating to evaporate a solvent, and a step of pulverizing the solid to obtain a powdery catalyst precursor.

[Claim ~~10~~9]

The method for producing a catalyst according to claim ~~8~~ 7 or ~~9~~8, wherein the carbon-containing gas comprises a hydrocarbon.

[Claim ~~11~~10]

The method for producing a catalyst according to claim ~~10~~9, wherein the hydrocarbon is an alkane having 2 to 5 carbon atoms.

[Claim ~~12~~11]

The method for producing a catalyst according to claim ~~10~~9, wherein the hydrocarbon is isobutane.

[Claim ~~13~~12]

The method for producing a catalyst according to any one of claims ~~10~~ 9 to ~~12~~11, wherein a volume ratio of the hydrocarbon to the carbon-containing gas is 1% by volume or more and 30% by volume or less.

[Claim ~~14~~13]

The method for producing a catalyst according to any one of claims ~~8~~ 7 to ~~13~~12, wherein a temperature at which the carbon-containing gas is brought into contact with the catalyst precursor is 300 °C or more and 1000 °C or less.

[Claim ~~15~~14]

The ~~process~~ method for producing a catalyst according to any one of claims ~~8~~ 7 to ~~14~~13, wherein a ratio (W/F) of an amount of the catalyst precursor to a feed rate of the carbon-containing gas when the carbon-containing gas is brought into contact with the catalyst precursor is 0.03g • min/ml or more and 0.5g • min/ml or less.

~~[Claim 16]~~

~~The process for producing a catalyst according to any one of claims 8 to 15, wherein the transition metal is Ni.~~

[Claim ~~17~~15]

The method for producing a catalyst according to any one of claims ~~8~~ 7 to ~~16~~14, wherein the carrier is at least one selected from the group consisting of silica, alumina, zirconia, and titania.

[Claim ~~18~~16]

The ~~process~~ method for producing a catalyst according to any one of claims ~~8~~ 7 to ~~16~~14, wherein the carrier is γ-alumina.

[Claim ~~19~~17]

The method for producing a catalyst according to any one of claims ~~8~~ 7 to ~~18~~16, wherein a ratio of a crystallite diameter of the transition metal supported on the catalyst to a crystallite diameter of the transition metal on the catalyst precursor when the carbon-containing gas is not brought into contact is 0.20 or more and 0.50~~0.80~~ or less.

[Claim ~~20~~18]

A method for producing an unsaturated hydrocarbon, the method comprising bringing a mixed gas comprising an alkane and carbon dioxide into contact with the catalyst according to any one of claims 1 to ~~7~~ 6 to produce an unsaturated hydrocarbon from the alkane.

[Claim ~~21~~19]

The method for producing an unsaturated hydrocarbon according to claim ~~20~~18, wherein in the mixed gas, a molar ratio of the carbon dioxide to the alkane is 0.1 or more and 1.9 or less.

[Claim ~~22~~20]

The method for producing an unsaturated hydrocarbon according to claim ~~20~~ 18 or ~~21~~19, wherein the alkane is an alkane having 2 to 5 carbon atoms.

[Claim ~~23~~21]

The method for producing an unsaturated hydrocarbon according to claim ~~20~~ 18 or ~~21~~19, wherein the alkane is isobutane.

[Claim ~~24~~22]

The method for producing an unsaturated hydrocarbon according to any one of claims ~~20~~ 18 to ~~23~~21, wherein a temperature at which the mixed gas is brought into contact with the catalyst is 300 °C or more and 1000 °C or less.

[Claim ~~25~~23]

The ~~process~~ method for producing an unsaturated hydrocarbon according to any one of claims ~~20~~ 18 to ~~24~~22, wherein a ratio (W/F) of an amount of the catalyst to a feed rate of the mixed gas when the mixed gas is brought into contact with the catalyst is 0.001g • min/ml or more and 1000g • min/ml or less.

[Claim ~~26~~24]

A method for producing an unsaturated hydrocarbon, the method comprising producing a catalyst by the production method according to any one of claims ~~8~~ 7 to ~~19~~17, and subsequently bringing a mixed gas comprising an alkane and carbon dioxide into contact with the obtained

catalyst to produce an unsaturated hydrocarbon from the alkane.

~~[Claim 27]~~

~~A method for producing an unsaturated hydrocarbon, the method comprising bringing a carbon-containing gas into contact with a catalyst precursor in which a transition metal compound is supported on a carrier to support carbon comprising fibrous carbon on the catalyst precursor, thereby forming a catalyst on which a transition metal and carbon comprising fibrous carbon is supported, and~~

~~bringing a mixed gas comprising an alkane and carbon dioxide into contact with the obtained catalyst to produce an unsaturated hydrocarbon from the alkane.~~

[Claim ~~28~~25]

The method for producing an unsaturated hydrocarbon according to claim ~~26~~ 24~~or 27~~, wherein in the mixed gas, a molar ratio of the carbon dioxide to the alkane is 0.1 or more and 1.9 or less.