Claims

Claim 1

A chemical reaction method which causes a reaction to proceed, a product of the reaction containing a component having a boiling point higher than that of a source material gas, progress of the reaction in a gaseous phase being restricted by a chemical equilibrium between a source material and the product,

said chemical reaction method using a chemical reaction device including:

a catalyst which promotes the reaction;

a transmission wall which allows a reacted gas produced by the reaction to pass therethrough;

a first heat exchange section positioned on an opposite side from the transmission wall with respect to the catalyst interposed between the first heat exchange section and the transmission wall; and

a second heat exchange section spaced apart via a space from the transmission wall,

said chemical reaction method comprising:

supplying the source material gas to the catalyst;

causing a first heating medium to flow through the first heat exchange section so that a temperature of a surface of the first heat exchange section which surface is in contact with the catalyst is maintained higher than a dew point of

the reacted gas;

causing a second heating medium to flow through the second heat exchange section so that a temperature of a surface of the second heat exchange section on a side of the space is maintained not higher than the dew point of the reacted gas; and

allowing a liquid obtained by condensation in the space to fall down so as to be separated from the source material gas.

Claim 2

The chemical reaction method as set forth in claim 1, wherein:

the reaction catalyzed by the catalyst is an exothermic reaction and carried out at a temperature higher than the dew point of the reacted gas by not less than 80°C;

the first heating medium has a temperature lower than an average temperature of a catalyst layer containing the catalyst by 5°C to 30°C; and

the second heating medium has a temperature lower than the dew point of the reacted gas by not less than 20°C.

Claim 3

The chemical reaction method as set forth in claim 1 or 2, wherein the source material gas contains a carbon oxide

and hydrogen, and the product contains methanol.

Claim 4

A chemical reaction device which causes a reaction to proceed, a product of the reaction containing a component having a boiling point higher than that of a source material gas, progress of the reaction in a gaseous phase being restricted by a chemical equilibrium between a source material and the product,

the chemical reaction device comprising:

a catalyst to which the source material gas is supplied and which promotes the reaction;

a transmission wall which allows a reacted gas produced by the reaction to pass therethrough;

a first heat exchange section positioned on an opposite side from the transmission wall with respect to the catalyst interposed between the first heat exchange section and the transmission wall; and

a second heat exchange section spaced apart via a space from the transmission wall,

a first heating medium being caused to flow through the first heat exchange section so that a temperature of a surface of the first heat exchange section which surface is in contact with the catalyst is maintained higher than a dew point of the reacted gas;

a second heating medium being caused to flow through the second heat exchange section so that a temperature of a surface of the second heat exchange section on a side of the space is maintained not higher than the dew point of the reacted gas; and

a liquid obtained by condensation in the space is allowed to fall down so as to be separated from the source material gas.

Claim 5

A chemical reaction device, comprising

a reaction container including at least one reaction tube that has a multiple structure and that causes a reaction to proceed inside the at least one reaction tube, a product of the reaction containing a component having a boiling point higher than that of a source material gas, progress of the reaction in a gaseous phase being restricted by a chemical equilibrium between a source material and the product,

each of the at least one reaction tube including:

an inner cylinder which allows a reacted gas produced by the reaction to pass therethrough;

an outer cylinder which is included in a first heat exchange section and inside which the inner cylinder is provided; and

a second heat exchange section which is provided

inside the inner cylinder,

the source material gas being supplied to a catalyst layer provided between the inner cylinder and the outer cylinder,

a second heating medium being caused to flow through the second heat exchange section so that a temperature of an outer surface of the second heat exchange section is maintained not higher than a dew point of the reacted gas,

a liquid obtained by condensation in a first space formed between the second heat exchange section and the inner cylinder being allowed to fall down so as to be separated from the source material gas,

a first heating medium being caused to flow on an outer side of the outer cylinder so that a temperature of an inner surface of the outer cylinder is maintained higher than the dew point of the reacted gas.

Claim 6

The chemical reaction device as set forth in claim 5, further comprising:

a storing section which stores therein, on a vertically lower side of the first space, the liquid and gas that has passed through the catalyst layer; and

a communicating tube which is provided inside the storing section,

the communicating tube forming, between the communicating tube and a surface of the second heat exchange section, a second space continuous with the first space,

a lower end of the communicating tube being positioned so as to be immersed in the liquid stored in the storing section.

Claim 7

The chemical reaction device as set forth in claim 6, wherein:

the storing section includes an exhaust section through which the gas stored inside the storing section is discharged; and

the exhaust section is located vertically above the lower end of the communicating tube.

Claim 8

A chemical reaction device, comprising

a reaction container including at least one reaction tube that has a multiple structure and that causes a reaction to proceed inside the at least one reaction tube, a product of the reaction containing a component having a boiling point higher than that of a source material gas, progress of the reaction in a gaseous phase being restricted by a chemical

equilibrium between a source material and the product,

each of the at least one reaction tube including:

an inner cylinder which allows a reacted gas produced by the reaction to pass therethrough;

a first heat exchange section which is provided inside the inner cylinder; and

an outer cylinder which is included in a second heat exchange section and inside which the inner cylinder is provided,

the source material gas being supplied to a catalyst layer provided between the inner cylinder and the first heat exchange section,

a second heating medium being caused to flow on an outer side of the outer cylinder so that a temperature of an inner surface of the outer cylinder is maintained not higher than a dew point of the reacted gas,

a liquid obtained by condensation in a first space formed between the inner cylinder and the outer cylinder being allowed to fall down so as to be separated from the source material gas,

a first heating medium being caused to flow through the first heat exchange section so that a temperature of a surface of the first heat exchange section is maintained higher than the dew point of the reacted gas.

Claim 9

The chemical reaction device as set forth in claim 8, further comprising:

a liquid storing section which stores the liquid therein on a vertically lower side of the first space;

a gas storing section which stores therein, on a vertically lower side of the catalyst layer, gas that has passed through the catalyst layer; and

an extension tube which is provided inside the liquid storing section,

the extension tube forming, inside the liquid storing section, a second space continuous with the first space,

a lower end of the extension tube being positioned so as to be immersed in the liquid stored in the liquid storing section,

the liquid storing section and the gas storing section forming respective different spaces.