Claims

[Claim 1] A method for producing light olefin, comprising:

a cracking step of introducing a naphtha feedstock to a cracking furnace to obtain a naphtha cracking fraction;

an ethanol conversion step of introducing a starting material containing ethanol to a reactor where the starting material is brought into contact with a catalyst to obtain an ethanol conversion fraction containing ethylene and propylene;

a combination step of combining at least a portion of the naphtha cracking fraction or a fraction derived therefrom with at least a portion of the ethanol conversion fraction or a fraction derived therefrom to obtain a combination fraction; and

a cryogenic separation step of introducing the combination fraction or a fraction derived therefrom to a cryogenic separation equipment to separate ethylene and propylene, wherein

a relationship between a content C_E of ethylene and propylene in the ethanol conversion fraction or a fraction derived therefrom and a content C_C of ethylene and propylene in the naphtha cracking fraction or a fraction derived therefrom in the combination step satisfies the expression (A):

$C_E > C_C$ ... (A).

[Claim 2] The method for producing light olefin according to claim 1, wherein a difference between the content C_E and the content C_C (C_E - C_C) in the combination step is 5% by mass or more.

[Claim 3] The method for producing light olefin according to claim 1 or 2, wherein a relationship between a propylene/ethylene mass ratio P/E_E in the ethanol conversion fraction and a propylene/ethylene mass ratio P/E_C in the naphtha cracking fraction satisfies the expression (α):

$-0.25 < (P/E_E - P/E_C) < 0.30$ ... (α).

[Claim 4] The method for producing light olefin according to any one of claims 1 to 3, wherein a relationship between a content C_{E_AP} of ethylene and propylene in the ethanol conversion fraction and a content C_{C_AP} of ethylene and propylene in the naphtha cracking fraction satisfies the expression (β-1):

$|C_{E_AP} - C_{C_AP}| < 20\%$ by mass ... (β-1).

[Claim 5] A method for producing light olefin, comprising:

a cracking step of introducing a naphtha feedstock to a cracking furnace to obtain a naphtha cracking fraction;

an ethanol conversion step of introducing a starting material containing ethanol to a reactor where the starting material is brought into contact with a catalyst to obtain an ethanol conversion fraction containing ethylene and propylene;

a combination step of combining at least a portion of the naphtha cracking fraction or a fraction derived therefrom with at least a portion of the ethanol conversion fraction or a fraction derived therefrom to obtain a combination fraction; and

a cryogenic separation step of introducing the combination fraction or a fraction derived therefrom to a cryogenic separation equipment to separate ethylene and propylene, wherein

a relationship between a propylene/ethylene mass ratio P/E_E in the ethanol conversion fraction and a propylene/ethylene mass ratio P/E_C in the naphtha cracking fraction satisfies the expression (α):

$-0.25 < (P/E_E - P/E_C) < 0.30$ ... (α), and

a relationship between a content C_{E_AP} of ethylene and propylene in the ethanol conversion fraction and a content C_{C_AP} of ethylene and propylene in the naphtha cracking fraction satisfies the expression (β-1):

$|C_{E_AP} - C_{C_AP}| < 20\%$ by mass ... (β-1).

[Claim 6] The method for producing light olefin according to claim 5, wherein the relationship between the content C_{E_AP} of ethylene and propylene in the ethanol conversion fraction and the content C_{C_AP} of ethylene and propylene in the naphtha cracking fraction satisfies the expression (β-2):

$0 \leq (C_{E_AP} - C_{C_AP}) < 20\%$ by mass ... (β-2).

[Claim 7] The method for producing light olefin according to any one of claims 1 to 6, comprising a first cooling step of introducing the naphtha cracking fraction or the combination fraction to a first cooling tower to obtain a first cooling fraction mainly containing olefin having 6 or less carbon atoms.

[Claim 8] The method for producing light olefin according to any one of claims 1 to 7, comprising a second cooling step of introducing the naphtha cracking fraction or the combination fraction or a fraction derived therefrom to a second cooling tower to obtain a second cooling fraction mainly containing olefin having 4 or less carbon atoms.

[Claim 9] The method for producing light olefin according to any one of claims 1 to 8, comprising a third cooling step of introducing the ethanol conversion fraction to a third cooling tower to obtain a cooled ethanol conversion fraction mainly containing olefin having 6 or less carbon atoms.

[Claim 10] The method for producing light olefin according to claim 9, comprising a compression and separation step of pressure-boosting the cooled ethanol conversion fraction using a compressor to obtain a light ethanol conversion fraction mainly containing olefin having 3 or less carbon atoms as a gas component and to obtain a heavy ethanol conversion fraction mainly containing olefin having 4 or more carbon atoms as a liquid component.

[Claim 11] The method for producing light olefin according to claim 10, comprising a recycling step of introducing at least a portion of the heavy ethanol conversion fraction as a portion of the starting material to the reactor.

[Claim 12] The method for producing light olefin according to any one of claims 1 to 11, comprising, after the combination step, a washing step of introducing the combination fraction or a fraction derived therefrom to a soda washing tower to obtain a washing fraction.

[Claim 13] The method for producing light olefin according to any one of claims 1 to 12, comprising, after the second cooling step and before the cryogenic separation step, a first compression step of pressure-boosting the fraction.

[Claim 14] The method for producing light olefin according to any one of claims 1 to 13, wherein a relationship between a ratio O_E of an amount of hydrogen and methane to a total amount of ethylene and propylene in the ethanol conversion fraction and a ratio O_C of an amount of hydrogen and methane to a total amount of ethylene and propylene in the naphtha cracking fraction satisfies the expression (1):

$O_E < O_C$ ... (1).

[Claim 15] The method for producing light olefin according to any one of claims 1 to 14, wherein the method satisfies any of the following (1) to (5):

(1) comprising:

a first cooling step of introducing the naphtha cracking fraction to a first cooling tower to obtain a first cooling fraction mainly containing olefin having 6 or less carbon atoms; and

a second cooling step of introducing the first cooling fraction to a second cooling tower to obtain a second cooling fraction mainly containing olefin having 4 or less carbon atoms, wherein

in the combination step, at least a portion of the second cooling fraction is combined with at least a portion of the ethanol conversion fraction or a fraction derived therefrom,

(2) comprising:

a first cooling step of introducing the naphtha cracking fraction to a first cooling tower to obtain a first cooling fraction mainly containing olefin having 6 or less carbon atoms; and

a second cooling step of introducing the combination fraction or a fraction derived therefrom to a second cooling tower to obtain a second cooling fraction mainly containing olefin having 4 or less carbon atoms, wherein

in the combination step, at least a portion of the first cooling fraction is combined with at least a portion of the ethanol conversion fraction or a fraction derived therefrom,

(3) comprising:

a first cooling step of introducing the naphtha cracking fraction to a first cooling tower to obtain a first cooling fraction mainly containing olefin having 6 or less carbon atoms;

a second cooling step of introducing the first cooling fraction to a second cooling tower to obtain a second cooling fraction mainly containing olefin having 4 or less carbon atoms;

a circulation step of introducing at least a portion of a second heavy fraction mainly containing hydrocarbon having 5 or more carbon atoms in the second cooling step to the second cooling tower; and

a first introduction step of introducing the combination fraction to the second cooling tower, wherein

in the combination step, at least a portion of the second heavy fraction is combined with at least a portion of the ethanol conversion fraction or a fraction derived therefrom,

(4) comprising:

a first cooling step of introducing the combination fraction or a fraction derived therefrom to a first cooling tower to obtain a first cooling fraction mainly containing olefin having 6 or less carbon atoms; and

a second cooling step of introducing the first cooling fraction to a second cooling tower to obtain a second cooling fraction mainly containing olefin having 4 or less carbon atoms, wherein

in the combination step, at least a portion of the naphtha cracking fraction is combined with at least a portion of the ethanol conversion fraction or a fraction derived therefrom, and

(5) comprising:

a first cooling step of introducing the naphtha cracking fraction to a first cooling tower to obtain a first cooling fraction mainly containing olefin having 6 or less carbon atoms;

a second cooling step of introducing the first cooling fraction to a second cooling tower to obtain a second cooling fraction mainly containing olefin having 4 or less carbon atoms;

a circulation step of introducing at least a portion of a second heavy fraction mainly containing hydrocarbon having 5 or more carbon atoms in the second cooling step to the first cooling tower; and

a second introduction step of introducing the combination fraction to the first cooling tower, wherein

in the combination step, at least a portion of the second heavy fraction is combined with at least a portion of the ethanol conversion fraction or a fraction derived therefrom.